Design of a Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa

Luyanda Ngomane

School of Construction Economics and Management

Faculty of Engineering and the Built Environment

University of the Witwatersrand, Johannesburg,

A thesis submitted to the in Fulfilment of the Requirements for the Degree of Doctor of Philosophy (PhD)

Johannesburg, January 2025

ABSTRACT

This doctoral study sought to examine how a self-improvement evaluation tool can be used to help South African category B4 municipalities acquire resilient infrastructure management capabilities. Category B4 municipalities are defined as mostly the rural municipalities with only one or two minor towns, characterised mainly with the failure to procure and manage sustainable infrastructure services. The study assumed that previous local government initiatives that were used to deploy professional support engineers to improve infrastructure management and service provision in category B4 municipalities, omitted the aspect of resilience as part of the support model. The study conceived the use of a capability maturity framework (CMF) as a self-improvement evaluation tool to help standardize organisational performance improvement towards resilience. This framework incorporates the mapping of project management knowledge areas into capability maturity improvement areas. It is postulated that these capability maturity improvement areas are critical in modelling the continuous capability improvement pathway required in managing infrastructure in category B4 municipalities towards resilience. As the infrastructure management capabilities progressively mature, so do the capability improvement areas collectively contribute towards resilience. This assumption is premised on the understanding that the more an organisation's infrastructure capabilities improve and mature, the more likely the management of infrastructure is to become resilient in improving service provision.

The study situated the concept of resilience as a context within which the design parameters of the capability maturity framework should be considered to model the infrastructure management for application in under-capacitated municipalities. This study identified 14 capability areas that provided a conceptual framework for assessing resilience in local government infrastructure management. These capability areas included budget alignment and infrastructure delivery cycles, development of construction procurement documentation, cost management, contract management. Since the CMF is centred on an ongoing improvement pathway of critical capacities on many levels with corresponding key process areas

at each level, this thesis should be seen as contributing to the improved understanding of how local government actions, processes, and measures can inform unique progression characteristics that are crucial in modelling a continuous improvement pathway towards resilient infrastructure management by Category B4 municipalities.

The approach to investigating this problem was to use a case-study research methodology. The qualitative investigation was conducted using semi and unstructured interviews, triangulated with a document review. Thematic data analysis was used and the OPM3 knowledge analysis (KA), assessment analysis (AA), and critical improvement areas (CIA) were well-organized as analysis components. The findings of the thesis reveal how organisations ought to deal with organisational capability realities based on the capability improvement tools and models rooted in and linked to the dynamic organisational circumstances.

The use of this framework is therefore recommended to support the building of capability maturity through the layered development of infrastructure management knowledge across the category B4 municipalities. In South Africa, the National and Provincial governments establish local government outcomes, with the objective of strengthening the strategic focus on government's service provision priorities. These service provision priorities allow municipalities and other sector departments to effectively carry out their constitutional and legislative obligations while also holding them accountable for their performance. Therefore, the implication of using the infrastructure management capability framework is that, category B4 municipalities will have a better understanding of and resilience in their infrastructure management responsibilities and advancement in terms of providing basic services.

Keywords: Capability improvement, Infrastructure management, Category B4 municipalities

DECLARATION

I declare that the material of this dissertation is solely my own work with the exception of specified and acknowledged references to the published work of others mentioned in the text.

To the best of my knowledge, it does not cover previously published work by others, or material that has been considered for the award of any other university degree.

Luyanda Ngomane is a candidate for the Degree of Doctor of Philosophy (PhD) at the University of Witwatersrand School of Construction Economics and Management.

Candidate: Luyanda Ngomane 

Signed at Johannesburg this 28th Day of January, 2025

DEDICATION

This is dedicated to:

- My cherished family, who encouraged my spiritual journey and offered prayers and spiritual lessons,
- To the hundreds of men and women in the local government sector, in pursuit of strategies and templates for resilient infrastructure management, and to rural municipalities in particular,
- To Professor Nthatisi Khatleli, who made this work happen, and
- Expressly to my Glorious King and Lord Jesus, and

This research is dedicated to you.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

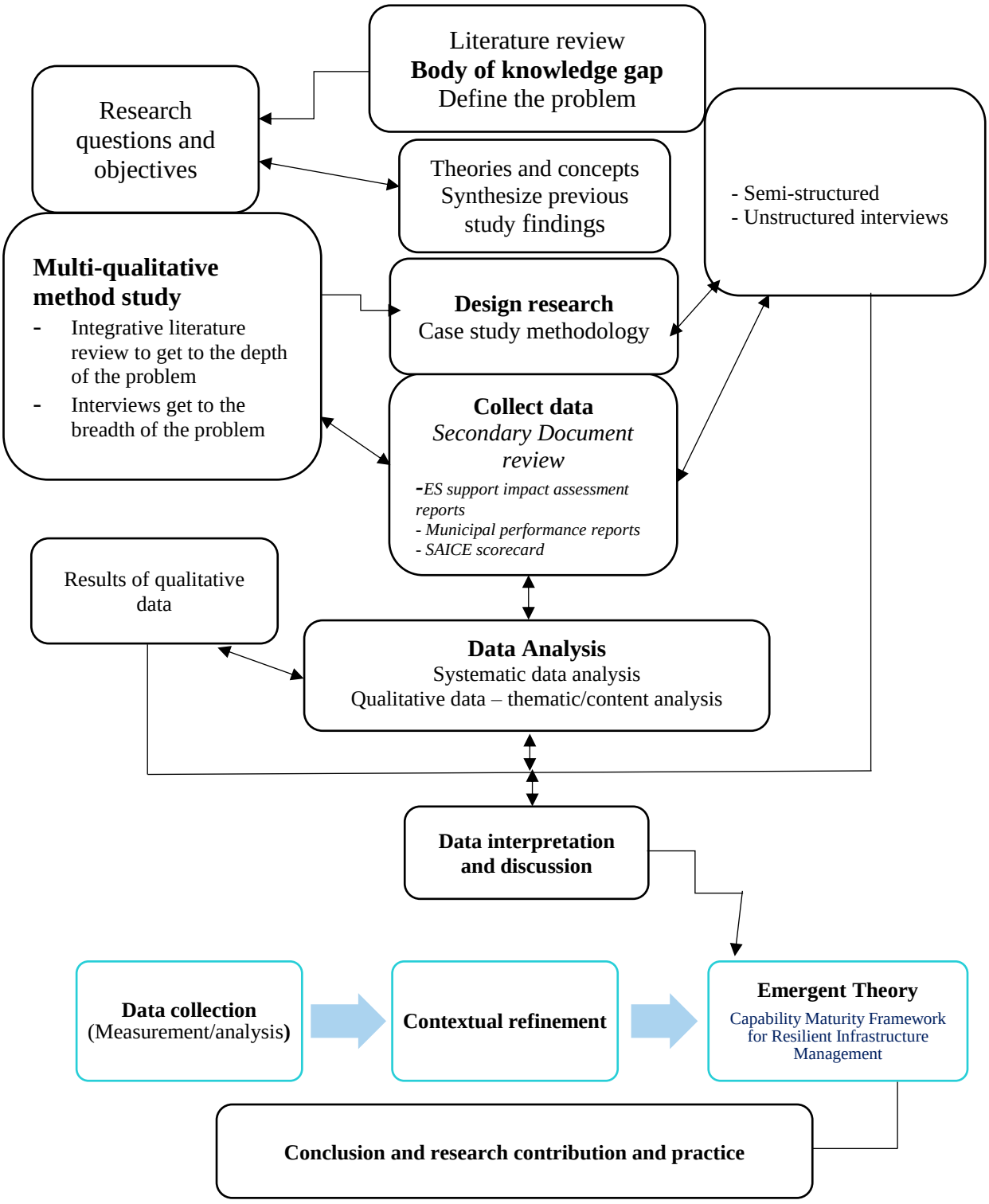
Abbreviation	Description
AA	Assessment Analysis
CIA	Critical Improvement Areas
CIDB	Construction Industry Development Board
CMF	Capability Maturity Framework
CMM	Capability Maturity Model
COGTA	Department of Cooperative Governance and Traditional Affairs
ES	Engineering Skills
ECSA	Engineering Council of South Africa
IIPSA	Infrastructure Investment Programme for South Africa
IDMS	Infrastructure Delivery Management System
IM	Infrastructure Management
KA	Knowledge Analysis
MIIF	Municipal Infrastructure Investment Framework
MSA	Municipal Structures Act
MDB	Municipal Demarcation Board
OPM3	Organizational Project Management Maturity Model
PMI	Project Management Institute
PMBOK	Project Management Body of Knowledge
RICS	Royal Institute of Charted Surveyors
SAICE	South African Institute of Civil Engineers
SDGs	Sustainable Development Goals
SEI	Software Engineering Institute
SA	Sub-Saharan Africa
WEO	World Economic Outlook

LIST OF TABLES

LIST OF FIGURES

RESEARCH PROCESS-FLOW

The research process flow diagram illustrates the visual organisation of the research, while depicting the roadmap used by the researcher to conduct the research (Bryman and Bell, 2021).



CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Service delivery for South African rural municipalities continually get stalled by the lack of the requisite engineering skills (ES) (COGTA, 2018). The awareness of the ES shortage in South African municipalities arose, after the South African Institute of Civil Engineers Professional Development and Projects (SAICE-PDP) published a research report on civil engineering skills (Lawless, 2015). Rural towns desperately require infrastructure management (IM) capabilities (Sansom, 2018), as they are the ones most affected. The Organising Framework for Occupations in South Africa, which classifies occupations, revealed a startling reality that, in local government, approximately 58% of all engineering professionals and technicians in related fields work in metropolitan cities, while only 9% are employed in urban municipalities (LGSETA, 2018).

In South Africa municipal legislative frameworks give credence to local government, and revenue generation is critical for municipal survival, as per the Act's prescripts in Sections 62(1) and 96(b) (MSA, 2000). The provision of services ought to utilize a substantial portion of every municipality's revenue. The work done by the DBSA Investment Framework in Municipal Infrastructure (MIIF) and in later years, Investment Programme for Infrastructure in South Africa (IIPSA) advocates that appropriate municipal own revenue reserves are crucial for attracting the requisite engineering skills (MIIF, 2021; IIPSA, 2021). The Demarcation Board studies undertaken revealed that the struggles to attract and retain highly skilled technical staff continues to leave rural municipalities with a weak own-revenue generation muscle, in comparison to financially sound municipalities (MDB, 2019). Rural towns cannot afford to offer competitive packages with their low revenue collection rates (MDB, 2019).

During apartheid South Africa, service provision activities in local government were mostly concentrated in urban areas, serving approximately 14 million people at a ratio of 20 civil engineering professionals per 100 000 people (Lawless, 2015). In metropolitan areas, a hierarchy of technical professionals was in place to manage infrastructure development, operation, and repairs of infrastructure, with a substantial rate and service base (Wall, 2021). The town engineer with years of experience in local government was the highest-ranking registered technical official and a skilled engineer in charge of infrastructure management (Handbook, 2019). Until the late

1980s, many technical employees were offered severance packages as part of local government reform and rationalization (Lawless, 2019).

In addition, the move to outsource design and construction and heavy reliance on external support, has ultimately affected local government's ability to manage infrastructure (IDMS, 2019). The Local Government Transitional Act 209 (1993) that mapped out a three-phased amalgamation plan of old racially structured institutions was proclaimed to deracialise the sector. The transitional phase was the initial restructuring step, which was a long and complicated interim phase (RSA, 1993). It was expected that the Transitional Local Government Act would effectively desegregate the local government system by integrating formerly racial communities. Critics (Brathwaite, 2018; Daniel et al., 2020) argue that the focus remains on metropolitan regions since apartheid's infrastructure discriminations and inequalities persist in rural communities.

The establishment phase was informed by the Constitution that envisioned a democratic local government providing efficient and equitable service to all citizens (RSA, 1996). With local government elections in 2000, the transitional phase that attempted to extend local government to rural regions through the formation of district councils came to an end (RSA, 1998). At a time when local government was being expanded to serve some 44 million people, service backlogs in rural municipalities were enormous (COGTA, 2018).

The Municipal Structures Act introduced municipal categories and provided powers and functions to such, based on these categories. The 257 South African municipalities are grouped in three main categories (A's, B's, and C's), and given legislative rights and functions prescribed in the Structures Act No. 117 and the Constitution.

The functions performed by municipalities are generally focused on providing reliable services to communities as defined by the Constitution. Services provided include energy, water and sanitation, refuse removal, roads and transportation, and fire-fighting (MSA, 1998).

Table 1.1: South African Municipal Categories Described

Municipal Category	Number of Municipalities	Municipal Category Descriptions
A	8	Metros with optimal executive authority and legislative powers
B1	19	Local municipalities with secondary cities with large budget
B2	26	A municipality with a central large town
B3	101	Municipalities with a modest urban population. No big town. The rural areas are characterized by commercial farming.
B4	59	Largely rural municipalities, there are only one or two mini towns in most of these municipalities.
C1	23	District municipalities assigned limited-service delivery tasks, and there is no water service authority
C2	21	Districts with significant responsibilities as a water services body

(Source: MDB, 2018)

Category A municipalities are the metropolitan cities characterized by high population density areas, with multiple business districts that are the main centres of economic activity (MSA, 1998). Municipal discrepancies in demographic, economic and settlement conditions, have resulted to a further sub-grouping of Category B municipalities into B1 to B4 (MDB, 2018). Whereas Category B1 are secondary cities with large municipal budgets.

Category B2, Category B3 respectively, are those municipalities with a collective executive system within the district and have large town centres and are relatively urban with no large town. B4 Category consist primarily of rural municipalities with one or two small settlements and high proportions of people living in traditional rural communities, notably the most underserviced areas in South Africa (MDB, 2019). Category C are mainly district municipalities that are responsible primarily for capacity building and district-wide planning whilst others may be water services authorities, another group of Category Cs have no service delivery function (RSA, 1996). According to government data, Performance Index (2019) the B4 municipal category has the least efficient municipalities when looking at the delivery of services, hence the study concentrated on the B4 Category.

Metros which are Category A are better serviced, averaging 0.44 registered professional engineers for every 10,000 people then 1.37 overall number of qualified engineers per 10,000 households (MDB, 2018). The category B-1 municipalities are well-serviced by technicians and technologists at the ratio of 1.56 engineering professionals per population of 10 000 people, while

the B3 and B2 municipalities with similar staff complement are a bit worse off at the ratio of 0.4235 (MDB, 2019). On the contrary, B4 Category municipalities are worse off, given the major skills constraints shown with engineering staffing ratios of 0.01 (MDB, 2018). MDB (2019) rejects even the establishment of some of these rural municipalities, instead recommends amalgamation.

During the consolidation phase when assessing the previous phases, it was observed that integrating rural areas and including informal areas increased the population that had to be served, yet there was no commensurate increased revenue base. Municipalities varied in their financial stability; some in metropolitan areas were financially stable despite challenges, such as aging infrastructure, growing service backlogs, and non-payment of services (MDA, 1998). The South African 2030 National Development Plan (NDP) (2011) envisions all public institutions in all spheres of government (including municipalities) being managed and effectively co-ordinated by skilled employees, capable of delivering quality services to communities. ES varied by local features in many rural communities, but failure to procure and manage sustainable infrastructure services was a common trait in virtually all B4 Category municipalities, contradicting the NDP vision (IDMS, 2019). As such, capacity-building support programmes were seen to address the imbalances in the engineering skills in low-capacity municipalities (LGSETA, 2018).

The intention of deploying engineering support consultants was to rebuild the technical departments in remote municipalities lacking ES (Rebuild, 2017). Since 2003, billions of rands in government capacity-building budgets have been spent on recruiting engineering support consultants in underperforming municipalities, including, but not limited to rural municipalities (Lawless, 2015; National Treasury, 2018; GGA, 2019). In supporting the consolidation phase, the South African government, through National Treasury, apportioned Project Consolidate Fund to the deployment of engineering support consultants and the development of infrastructure management capacities in remote municipalities (Natonal Treasury, 2020). Lephoto and Khatleli (2019) contend that after the support was withdrawn, a significant engineering skills gap remained. Lawless (2015) stated that the shortage of ES remains amongst the ‘historic 'worst capacity failures'. Inevitably, municipal service provision functions outlined in the Constitution remain unrealized (GGA, 2019; National Treasury, 2018; MDB, 2019).

This research study advocates for significant structural shifts in improving technical infrastructure management capacities in rural communities. The study claims that prior capacity-building projects involving the deployment of supporting engineers have not been sustainable, as

these municipalities' engineering services departments were still far from being strongly engineering dominated (Ngomane, 2018). Central to this research is the design of a suitable framework aimed at infrastructure management resilience in municipalities with technical skill deficits.

1.2 INFRASTRUCTURE MANAGEMENT CAPABILITIES, CAPABILITY MATURITY MODELS AND RESILIENCE

1.2.1 Infrastructure Management Capabilities

According to MIIF (2021) infrastructure refers to the capital projects required to provide services such as water, sanitation, roads, and solid waste disposal. This infrastructure is necessary for the provision of these reliable services (COGTA, 2018). While the building of new infrastructure requires considerable funds, maintaining the current infrastructure is just as crucial (Canadian Infrastructure Report, 2019). The term '*capability'* as defined by Park (2021) is a set of resources and abilities essential for achieving measurable results in executing tasks under specified conditions and to specific performance standards. Schriber (2020) views capabilities as business re-engineering abilities, whilst being responsive to conditions that may otherwise threaten their viability. RICS (2017) defines capabilities as the resources a organisation uses to create value and meet organisational goals. describes people capabilities, in the context of people as a person's skills and resources using those resources to accomplish their goals. The Engineering Council of South Africa's (ECSA) survey report on South Africa's engineering skills pool (ECSA, 2021), refers to the civil engineering skills as capabilities to design, construct, and manage infrastructure. Likewise, RICS (2017) puts it concisely that IM are capabilities to co-ordinate decisions on infrastructure investment planning and programming, design and construction, operation, and maintenance of public infrastructure assets.

The MSA (1998) delineates capacity as potential and competency found within the municipality which includes financial, physical and manpower resources to provide infrastructure services. In South Africa, the capacity and engineering skillsets to exercise powers and perform service provision functions vary between categories of municipalities (MDB, 2019). The variable ES has resulted in service provision deficiencies, particularly in the rural Category B4 municipalities, which still struggle to attract the requisite mature ES to perform the municipal infrastructure management functions (MDB, 2018). Given the substantial skills constraints evidenced by engineering staffing ratios of 0.01 in Category B4 towns, they are in a worse state in managing

infrastructure (MDB, 2018). The quest in this research context was the improvement of these infrastructure management capabilities, using a structured improvement path. The next section explores capability maturity models (CMM) and their relevance to this research.

1.2.2 Capability Maturity Models

The Software Engineering Institute (SEI) accepted maturity models as a systematic improvement pathway in fulfilling daily obligations, the individual transitioned from impetuous to tested, seasoned employee capabilities previously utilised in software engineering. The model's goal was to meet specific specifications and features of Government agencies. According to Khraiwesh (2020), proven practises in a certain discipline uses CMM to assess and develop the capability of a group in that field. CMMs, in software engineering industry, were effective in process improvement (SEI, 2021). There has been an increasing interest in benchmarking corporate project management practices since the 1990's, (Winch and Sergeeva, 2022) putting an emphasis on project management as an organisational competency. Simultaneously, in the projects' environment, organisations apply CMM to attract, nurture, and retain skills required to continuously improve project management capability (PMI, 2017). By institutionalising the notion of project management maturity, PMI (2017) had a widespread influence on the discourse. CMMs are widely utilised in the field of organisational performance improvement (PMI, 2021).

The capabilities framework facilitates the identification of a variety of social inequalities in all spheres of development that could be organisational policy targets. As espoused by the PMI (2017), the practitioner's perspective was set against the backdrop of project management's evolution from the use of tools and processes on stand-alone projects to the project management concept as an organisational capability. Several factors influence project management performance, including project management capability (PMM). PMM highlights areas of potential for project performance enhancement. It is crucial for the organisation to continually assess every aspect of project management procedures that facilitate growing project management maturity. According to Blichfeldt and Eskerod (2017), the corporation uses a tried methodology to benchmark organisational project management capabilities, formulate a growth plan, and confirm results through follow-up assessments. The design parameters of various capability maturity models are presented in Table 1.2.

Table 1.2: Capability Maturity Models

Capability Models	Design Parameters	Reference
Maturity Model in Organization Project Management (OPM3)	Apply a 5-stage epistemology to heighten organizational weaknesses, and advocate for constant improvement capacities	PMI Publication (2017)
Integrated Capability Maturity Model (CMMI-DEV).	Adopt process configuration steps to improve productivity in organizations	SEI. (2021) Integrated Capability Maturity Model (P-CMM) Available at: http://www. CMU/SEI-2021-TR-003pdf (Accessed: 30 April 2022)
Project, Programme, Portfolio Management Maturity Model (P3M3)	Use a 5-stage process to improve and evaluate capability maturity stage	PMI. (2017) The Project Management Maturity Model. 23 (4): 50-58.
People Capability Maturity Model(P-CMM)	5-stage framework for capability maturity to help prioritize their improvement actions	SEI. (2021) Capability Maturity Model (P-CMM) Available at: http://www. CMU/SEI-2021-TR-003pdf (Accessed: 30 April 2022)

Source: (Author)

1.2.3 Resilience

Various studies in the field of resilience (Vivek, 2021; Mirti,2018; Linnenluecke, 2017), across several research streams, have demonstrated fragmented resilience research, which, amongst others, includes employee capabilities, organisational resilience, functionality, adaptability, organisational responses to external and internal threats and desired level of maturity. Specific definitions and concepts were developed to measure resilience, as outlined in Table 1.3.

Table 1.3: Resilience Definitions

Linnenluecke (2017) describes resilience as a skill set that can be learned and developed	Linnenluecke (2017)
Since the 1970s, the concept of resilience was designed for understanding ecosystems' capacity to absorb disturbance without a change in its original state	Holling (1978)
Resilience is the system's ability to absorb, withstand, recuperate and reorganise the situation in the wake of disturbance whilst continuing to function normally	Global CEO Survey (2021)
Resilience is an improvement approach essential for adapting challenges into successes	Mirti (2018)
The Rockefeller Foundation's 100 Resilient Cities initiative (2019) adopted this resilience definition '*individual capacity, communities, industries, and structures within a city to withstand, adapt, and mature, despite the prolonged pressures as well as severe shocks they experience'*	Rockefeller Resilient Cities Initiative (2019)

Source: Author

Noticeable common themes that emerged across these definitions were employee capabilities, capacity, adaptability, desired level of capability maturity and organisational performance. Within this research context, resilient IM was viewed as the capability of the B4 Category municipalities to survive, adapt, and grow service provision, despite the pressure to function independently of external ES support provided. The term '*service provision'* has been used all over the world to be the provision of essential community services, such as housing, water and sanitation, roads, electricity, and sewerage infrastructure, (ACSE, 2017; Ghosh, 2017; Canadian Infrastructure Report, 2019) and it is no different in South Africa (RSA, 1996; COGTA, 2018). Service provision is essential to the vitality of communities and the quality of life of their residents (Ghosh, 2017). Legislative frameworks deem these essential services to communities (whether provided by a public or private entity) as a service that would threaten or severely affect the community's security, well-being, or welfare if it were not provided (RSA, 1996; MSA, 1998; National Treasury, 2018). Rooted in the capability approach, the study stated that approaching infrastructure management difficulties through the lens of resilience could help identify policy objectives across the diversity of social experience. The concept of resilient infrastructure management capabilities remains crucial for the large and long-lasting infrastructure projects for future delivery in the B4 municipal category. The development of the framework evolved in an effort to guarantee continuity of municipal services.

1.2.4 Justification of Capability Maturity Models

In project management literature, capability theories are presented in the form of standards, bodies of knowledge, and models (Flyvbjerg, 2021; Brathwaite, 2018). The central notion for capability maturity models (CMM) has constantly been the improvement progression in key capabilities (PMI, 2017). Predominance of CMMs is designed, based on the concept of a gradual and progressive capability improvement pathway. Critical capacity advancement levels are completed, when specified maturity levels are reached (PMI, 2019). Following the significant success of CMM in promoting methodical procedures for improving staff skills and knowledge in ICT organisations (Rodrigo, and Perera, 2017), the concept of CMM has recently permeated the construction sector (Aghimien et al., 2021). CMM presents a deliberate opportunity for organizations' to progressively improve the capabilities (Brathwaite, 2018).

The PMI standards committee defines the nine PMBOK knowledge domains as a set of competencies and skills needed to consistently improve project management capabilities (PMI, 2017). In this study context, the knowedge areas are used to compare PMBOK standard project

management practices in managing infrastructure between previously deployed support engineers and the existing technical personnel in B4 Category municipalities. Similarly, the work of the National Treasury infrastructure delivery management unit ensures that experts in the built environment are strategically positioned with the necessary skills to make informed decisions (IDMS, 2019).

This is especially true in this study, as the B4 Category municipalities needed the necessary capital, skills, and expertise in managing infrastructure. Looking at the collection of project management capability maturity models, there was no unique capacity maturity framework for the B4 category of municipalities, to encourage resilient capabilities in managing infrastructure. The PMI Organisation Project Management (OPM3) model was used as a template to deduce the applicability of the causal relationship in nurturing skills and continuous improvement of the infrastructure management capabilities. This was in anticipation of the causal relationship between employee IM capability maturity that collectively builds the organizational IM resilience, which ultimately impacts on the organisations' continued performance (PMI, 2017).

The objective of this research is to assist these municipalities to recognize their present ES capability maturity and the recommended improvement pathway towards resilience. The Maturity Framework for improving the capabilities in the B4 Category municipalities was considered as a pragmatic step in this research area.

1.3 INFRASTRUCTURE MANAGEMENT CAPABILITY EXPERIENCES FROM OTHER COUNTRIES

Municipalities worldwide face inadequate infrastructure management capacities (RICS, 2017). In Canada, rural municipalities are unable to meet service provision expectations, even though municipalities hold around two-thirds of the vital infrastructure assets that affect Canada's quality of life (Rebuild, 2017). The inability to provide services is due to the poor municipal tax base and infrastructure management capacities (ICMA, 2020). To date, federal gas tax transfers have been used to help expand infrastructure management capacity in a way that was less state-centric, more bottom-up, and better responsive to the changing local conditions in Canadian municipalities (ICMA, 2020). The lack of adequately trained human resources has been the primary, and perhaps, the most problematic challenge in rural Canadian municipalities (Tomas, 2022).

This has resulted in high dependency on consultants' aid for successful municipal asset management (Rebuild, 2017). This is true in South Africa, where engineering consultants are used to assist in the development of infrastructure management capacities in rural towns (COGTA, 2018). Rural communities frequently experience a shortage of service supply, due to the lack of ES and the problem appears to be worsening, even in the BRICS countries (Sansom, 2018). Similarly, Sub-Saharan Africa (SA) local government sector is hampered by a lack of engineering skills, deferred maintenance backlogs, and infrastructure that is functionally obsolete. According to Sansom (2018) only 5% in the rural communities are supplied with reticulated water. Even though countries should have achieved the 2030 vision for equitable access to well-managed water services, Sustainable Development Goals (SDGs) Objective 6.1 remains unmet (UNICEF, 2017).

Nine of the 17 SDGs rely on engineering skills, and several others, such as health care and education infrastructure, dictate the existence of engineering facilities (UN-Water, 2017). Likewise, there are still inconsistencies between these SDG universal targets and country realities in most SA countries (UNICEF, 2017). The World Energy Outlook (WEO) research findings listed Sub-Saharan Africa as the world's least electrified region, with 80 percent of rural families lacking access to electricity (WEO, 2019). The PMI (2017) has considered using capability maturity models (CMM) to regulate organisational performance improvement. The use of CMMs in accelerating long-term infrastructure planning and delivery has sparked global interest (Gal, 2017; Patrucco et al., 2019). The study explored the practise of CMF to promote resilient infrastructure management capability in B4 municipal category.

1.4 PROBLEM FORMULATION

Over the years, South African rural municipalities have been unable to eradicate historical infrastructure backlogs, while dealing with current maintenance backlogs (StatsSA, 2022). Engineering skills varied by local requirements, and feature in many rural communities, according to Andreas, (2021), but failure to procure and manage sustainable infrastructure services was a common trait in virtually all Category B4 municipalities, thus contradicting the NDP 2030 vision of having public institutions capable of delivering quality services to communities (IDMS, 2019).

The advancement and harmonization of engineering skills and standards is critical to the successful implementation of NDP Agenda 2030. According to the reports published by Statistics SA on the Community Survey service delivery indicators, Category B4 municipalities have provided water, sanitation, and refuse removal services to less than fifty percent of the households, a situation ascribed to their lack of ES and IM capabilities (StatsSA, 2022). Several weaknesses, including a low revenue base, have rendered Category B4 municipalities incapable of recruiting, and procuring ES to manage infrastructure and carry out service provision functions (Brathwaite, 2018). This section introduces resilience as a critical concept in this research.

As stated in Shamout et al. (2020), the resilience concept is a global discourse progressively being applied in different sectors, including business and management research. The study adopted the resilience definition by the Global CEO Survey (2021), as an ability of the system to absorb, endure, recover from, as well as adjust to new situations, while continuing to function in essentially the same way. The study has found the definition by the Global CEO Survey (2021) to be the most relevant for the phenomenon under consideration, due to its inclusiveness and resonance with the current situation in Category B4 municipalities. Furthermore, the Global CEO Survey definition provided unique progression features with composite organisational capabilities and routines.

These features were critical in modelling the continuous capability improvement pathway in managing infrastructure, in the B4 category of municipalities. Brathwaite (2018) perceived the lack of maturity in organizational project management capabilities, as a resilience threat. Resilient infrastructure management capabilities have been an Achilles heel for many South African rural towns, as previous support interventions have proven to be unsustainable (MDB, 2018). There has been no systematic transfer of ES to the existing technical personnel in municipalities during the implementation of engineering support programmes (Aghimien et al., 2021). This perpetual infrastructure management deficit in Category B4 municipalities points towards the resilience gap in the current engineering skills support models (Conz and Magnani, 2019; Duchek, 2019).

The work done by Andreas (2021) on resilience capabilities provides insight on attributes and resources to nurture the resilience phenomenon, hence the organisational resilience is adopted as the foundation for this empirical research. This study situates resilience as a context within which the design parameters of the capability maturity framework should be considered to model the capability improvement process, for application in under-capacitated municipalities.

This study modelled the resilience of infrastructure management capabilities in the B4 municipalities, using the resilience definition endorsed by the Global CEO Survey as a lens. The Global CEO Survey (2021) maintains that organisations must be able to deal with organisational capability realities as they stimulate or impair the organisational ability to deliver on their purpose, which in turn, impact organisational resilience. The work done by Andreas (2021) suggested that resilient organisations retain competent skills sets, enabled the adaptation of in-house resources and capabilities requisite to varying conditions. The goal of this research is to fill the knowledge vacuum by developing an emerging framework for capacity maturity and infrastructure management resilience in Category B4 municipalities. It is hoped that the suggested capacity maturity framework would serve as a model for municipalities in developing the necessary capabilities for continuous service delivery.

1.4.1 Problem Statement

Efficient engineering skillsets in South Africa are skewed in favour of the big municipalities, disadvantaging the rural based Category B4 municipalities. The want of the requisite skills in the rural municipalities translates into poor infrastructure management capabilities, resulting in poor service provision. There is no practical study that contributes a Capability Maturity Framework (CMF) for a continuous improvement pathway in infrastructure management capability, in Category B4 municipalities. The poor infrastructure management capabilities nuances are an impediment to efficient service provision and warrant a further enquiry, as proposed by this study.

1.4.2 Justification of the Problem

Organisations pursuing resilience regard the three basic components of people skills, procedure, and technology as crucial to their continued existence (SEI, 2021). B4 Category municipalities still struggle to achieve resilience in all three areas. The MDB reported that only 27 of South Africa's 257 municipalities employ roughly three-quarters of professional engineers and technicians in the municipal system (MDB, 2018). Similarly, B4 Category municipalities lack the requisite infrastructure management resilience to solve service delivery difficulties, (MDB, 2018).

Work done on municipal financial viability proved that rates-based revenue-generation is a major revenue stream for B4 Category municipalities (MIIF, 2021; IIPSA, 2021). MIIF statistics revealed that 20% of the Category B1 municipal total revenue was generated from rates, whereas Category B2 net 28% and Category B3 generate 23% (MIIF, 2021). Likewise, B4 Category

municipalities should net 47%, which accounts for almost fifty% of their own revenue that should be generated from rates, yet these municipalities contribute only 4% personal income tax to SARS (MIIF, 2021). The ability of the state to raise revenue is inextricably related to its ability to implement solid policies, and there is reason to believe that hiking taxes remains a good way to improve overall governance capabilities.

IIPSA (2021) posits that within the local government sector, sources of revenue are crucial for promoting fiscal autonomy, however, the revenue collection rated have proved to be on the low side. The fiscal split is inequitable, with local governments receiving only about 17% of the equitable share compared to 83% for provinces (MIIF, 2021). Municipalities, on the other hand, take responsibility for 46% of constitutional service provision functions and receives around 9.1% of the national budget. As a result, these circumstantial elements have exposed the fiscal distress in B4 Category municipalities, as well as the resultant inability to hire the desired skilled engineers, as opposed to financially sustainable municipalities (MDB, 2019).

The B4 category of municipalities accomplish the lowest performance on service delivery scores in the Government Performance Index (2019), as a result, the study is confined to municipalities in B4 Category to have a deeper understanding of the situation. This denotes what Roberts and Dowling (2002) perceived as a lack of organisational resilience. Work done by SEI (2021) suggested that capability improvement tools and models ought to be rooted in and linked to the dynamic organisational circumstances. Andreas (2021) posits that recent capability maturity models (CMM) have disregarded resilience in their design characteristics, making them inadequate for B4 Category towns. As a result, the conventional CMM were oblivious of the specific capabilities of these towns. The research goal is the framework design founded on the current CMM's maturity stages but has incorporated the resilience stage in the design criteria, for use in B4 Category municipalities.

1.5 RESEARCH AIM

The aim of the study is to develop a capability maturity framework for infrastructure management resilience in Category B4 municipalities.

1.5.1 Research Objectives

The project is steered by the following research objectives to attain the study's aim:

1. To critique the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel.

2. To identify the skills in infrastructure management that were employed by previously deployed support engineers to cultivate resilient service provision in Category B4 municipalities.

3. To assess the infrastructure management maturity of Category B4 municipalities using the capability maturity model (OPM3)

4. To identify the key areas of improvement that should be incorporated in the resilient infrastructure management capabilities maturity framework.

5. To develop a resilient infrastructure management framework for municipalities in Category B4.

1.6 RESEARCH QUESTION

Developing a research question is a fundamental step in undertaking any academic project. The main question guiding this study is: -

"How can infrastructure management capabilities be more resilient in the category B4 municipalities?"

1.6.1 Sub-Questions

The study seeks to give answers on how municipalities' infrastructure management capabilities in Category B4 can be made more resilient. The sub-questions are outlined as follows:

1. How does the usage of project management approaches by current technical staff in Category B4 municipalities compare to the project management approaches for infrastructure management approaches employed by former support engineers?

2. What infrastructure management skills were used by previously deployed support engineers to maintain reliable service delivery in Category B4 municipalities?

3. What are the various maturity stages in infrastructure management of Category B4 municipalities assessed using the capability maturity model (OPM3)?

4. What are the most important areas for capacity improvement that should be included in the resilience framework?

5. How can municipalities in Category B4 improve their resilient infrastructure management capabilities empirically?

Table 1.4: Summary of Sub- Questions and Objectives

To compare the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel.	How does the usage of project management approaches for managing infrastructure by current technical employees compare to the project management approaches employed by previously deployed support engineers?
To identify the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities.	What infrastructure management skills were used by previously deployed support engineers to maintain reliable service delivery in Category B4 municipalities?
To identify the key improvement areas that should be incorporated in the resilient infrastructure management capabilities maturity framework.	What are the key areas for capacity improvement that should be included in the resilience framework?
To assess the maturity of Category B4 municipalities in infrastructure management using the capability maturity model (OPM3)	What are the various maturity levels in infrastructure management of Category B4 municipalities as assessed through the capacity maturity model (OPM3)?
To develop a resilient infrastructure management framework, drawn from capability maturity models for municipalities in Category B4	How can municipalities in Category B4 improve their resilient infrastructure management capabilities empirically

Source: Author

1.7 RATIONALE OF THE STUDY

Capability Maturity Models are used by organisations to attract, develop, and retain the talents needed to improve project management capabilities over time (SEI, 2021). Organisations can also utilize capacity maturity models to chart a process to continuous improvement of key capabilities at various organisational levels (PMI, 2017). In local government, the systematic, continuous improvement that is important to the management of infrastructure portfolios,

programmes, and construction projects, with the goal of achieving service provision objectives, is an issue that must be solved.

Aghimien et al. (2021) acknowledge that there are limited studies on the capability maturity models for resilient infrastructure management. Where some research was undertaken about infrastructure management capability maturity, the resilience component in Category B4 towns has not been applied. Category B4 municipalities are affected by unique capability features, unconsidered by the standard CMM, so the study intends to include the resilience component in the design parameters (MDB, 2018). The work done by SE, (2021) on traditional CMMs provided a solid foundation on which to study any nuances in the behaviour of Category B4 municipalities' resilient infrastructure management needs. CMM presents a deliberate opportunity for municipalities to progressively improve the capabilities (Brathwaite, 2018). Central to this study is the acknowledgement that resilience increases service provision benefits in municipalities with robust infrastructure management capabilities. During apartheid South Africa, a hierarchy of technical engineering skills in urban metropolitan municipalities to handle infrastructure development, management, operations, and maintenance were in place, with a significant rate and service base (Lawless, 2019). The town engineer was the highest-ranking registered technical official in charge of infrastructure management, with years of experience in local government (Lawless, 2019).

As a result of the extended service coverage to more communities in the new South Africa, service provision backlogs were enormous in previously unserved rural towns (MDB, 2018). The government's decision to outsource infrastructure design and construction work in local government resulted in a large reliance on external support (ICMA, 2020). The reliance on external ES has harmed the ability of local governments to manage infrastructure (IDMS, 2019). The work done by Lephotho and Khatleli (2019) on the efficacy of expat professionals engineering skills (ES) transfer to candidate engineers in South African mega construction projects (MCPs) found that there is no systematic transfer of ES during the implementation of MCPs.

Work done by various authors and institutions (Lawless, 2015; National Treasury, 2018; GGA, 2021) since 2003, specify that billions of rands have been spent on recruiting engineering support consultants in underperforming municipalities, including but not limited to rural towns, as part of government capacity-building budgets. Although the government allocated these funds to the deployment of engineering support consultants and the development of infrastructure

management capacities in remote municipalities, Lephoto and Khatleli (2019) contend that after the support was withdrawn, a significant engineering skills gap remained.

These findings further brought about this study's assumption that previous ES support programmes to improve infrastructure management capabilities lacked the resilience component. Attracting, developing, and retaining the ES to enhance delivery and management of infrastructure is the core of the problem in Category B4 municipalities. Capability improvement strategies and models must be rooted in organisational realities (SEI, 2021).

1.8 RESEARCH METHODOLOGY

The rationale of the methodological approach remains crucial, based on the philosophy guiding the research. A pragmatic philosophical viewpoint has been chosen for this study against the positivists' law-like generalizations that have little or no bearing on causation, which was crucial for this study's investigation (Johnson, Russo and Schoonenboom, 2017). Even though the pragmatist philosophical attitude implies an indeterminate domain, researchers who take a pragmatist approach are more interested in practical consequences that are waiting to be justified, which was the focus of this study.

In developing the capability maturity model for resilient infrastructure management, the study employed an explanatory case study research enquiry. Yin (2017) defines a case study as a qualitative empirical research method that identifies a unit of analysis in its real-world setting. The six municipalities purposefully sampled in the North West and Eastern Cape Provinces were the unit of analysis, where the case study evidence was collected. The case study approach is used by scholars from numerous fields to build on theory to elucidate a phenomenon or give a foundation for implementing a response to a problem.

Unlike the positivist-oriented research which prefers quantitative methods to gather knowledge, this study did not contain a large sample of quantitative data, except secondary documents and assessment scores measuring existing capability levels in Category B4 municipalities. In view of that, the goal of this study was to model how technical personnel skills should be enhanced to improve infrastructure management capabilities, thus there was qualitative data collected through interaction with people. In developing the municipal institutional capacity model, the researcher used a non-positivist explanatory paradigm.

Actors were able to interactively construct reality using the OPM3 model to assess the level of IM maturity in the B4 municipal category, conduct gap analysis on resilience, and design a capability maturity framework by analysing municipalities' infrastructure management capability development levels in the B4 category. The framework development approach was based on the OPM3 maturity model's existing 5-stage epistemology (PMI, 2017). The researcher drew conclusions from the known OPM3 premise alongside with the established expert group in the built environment Douven (2021) and drawing inspiration from the existing CMM as outlined in Saunders, Lewis and Thornhill (2019). The framework was validated externally through the expert verification workshop, a methodical approach consistent with the methodology used for this study, wherein the expert panel was involved in the development and refinement of the capability maturity framework for resilient infrastructure management in Category B4 municipalities.

1.8.1 Justification of the Research Methodology

The proven choice for this study was the case study design, entrenched in answering how Category B4 municipalities are suffering the largest infrastructure management issues (Yin, 2018). Creswell (2018) states that case studies have a unique strength that accommodates multiple epistemological orientations, whilst linking specific methodological challenges, processes, and outcomes.

The study enquiry was limited to the Eastern Cape and North-West Provinces, out of the nine provinces of South Africa. The municipalities from these provinces were selected as case study municipalities representative of the precise attributes of the Category B4 municipalities under enquiry. Category B4 municipalities in these provinces record the lowest scores on service delivery indicators and have the most vulnerable technical services departments respectively (MDB, 2018; LGSETA, 2018; National Treasury 2018).

Likewise, the province of the North-West, was among the most overburdened on municipal technical services and was deemed a suitable case to study the design of a capability maturity framework for resilient infrastructure management. The case study provinces had a unique strength that accommodates multiple epistemological orientations, whilst linking specific methodological challenges, processes, and outcomes.

In tweaking the existing CMM, the study introduces the sixth stage of the "*resilience component*". The hope is that this study would make a difference in terms of policy, most probably be useful

even to the policymakers in changing the ways public infrastructure delivery is implemented. Also, the proposed framework will be useful to technical managers as a reference for planning and implementing measures to improve resilience of infrastructure management capabilities in the category B 4 municipalities.

1.9 RESEARCH PROCESS FLOW

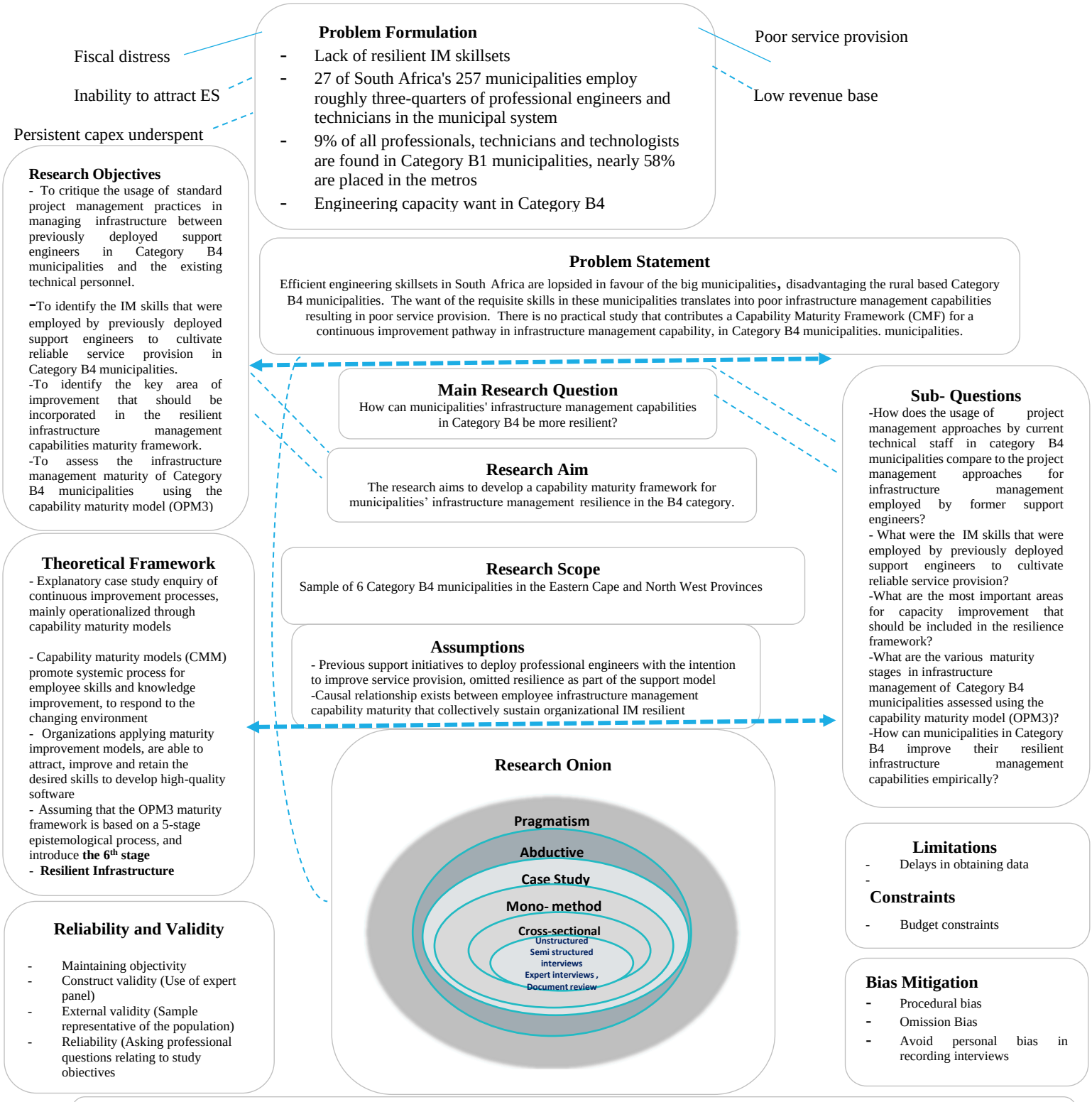


Figure 1:1Research Process Flow

Source: Author

1.10 STRUCTURE OF THE THESIS

This section outlines and guides the reader in understanding the contextual background of the infrastructure management capability challenges that South African Category B4 municipalities face, as well as the theoretical foundations that were used to develop the framework. The expert verification of the areas and finally the development of the framework is described. Finally, the framework developed is presented. The contents of each chapter are summarised:

- **Chapter One: Introduction**

  It serves as an introduction to the dissertation and an executive summary of it. This chapter provides an overview of the setting in which the research challenge exists. The research problem, aim and objectives are also stated in this chapter. Following that, the research methodology is detailed, the scope of the research is established, and thesis structure is presented.

- **Chapter Two: Literature Review**

  This chapter focuses on understanding service provision and infrastructure management in the context of resilient engineering capabilities in South African municipalities. This is accomplished by first describing the worldwide local government system, then the Sub-Saharan countries, and finally South Africa. Key concepts in this study service provision, engineering skills, capability models and resilience are defined in this chapter. The lack of engineering skills and infrastructure management capabilities and its effects on service provision, particularly in the context of Category B4 municipalities were covered in this chapter. Despite the reality of engineering skills shortage challenges, there are apparent benefits of obligating to enhancing infrastructure management resilience in rural municipalities.

- **Chapter 3: Research Methodology**

  The chapter discusses the study's theoretical framework and gives the conceptual foundation for the investigation. Various capability maturity theories and its origins is discussed in this chapter, thus providing an overall basis for this study. The chapter gives a review of the OPM3 (organisational project management theory). The chapter identifies an important gap in literature concerning the capability maturity framework for resilient infrastructure management for Category B4 municipalities. The methodology used in the

research is presented and supported here. This chapter covers the philosophical foundation that guided the research and the case study approach utilized to elucidate the phenomenon under examination.

The research question is developed based on the topic under consideration, and the philosophical viewpoint is taken to provide a solution to a problem. The chapter also covers how the case study research design was used during the project's execution in terms of the qualitative approach, data collection methods, research design, and data analysis and verification.

- **Chapter Four: Presentation of Research Data and Data Analysis**

  Four case study municipalities (Mhlontlo, uMzimvubu, Nyandeni, Mnquma located in the Eastern Cape and Moretele in the North West Provinces of South Africa) are presented. This chapter provides the background information to the four case study municipalities, including the demographics and service provision capabilities. Presentation of contrasts and similarities discovered during data analysis both within and across the Mnquma, Nyandeni, Moretele, and Mhlontlo Category B4 municipal settings. The chapter further presents Creswell's five stage data analysis procedure, which was useful in allowing distinct gathering, analysis, and interpretation of qualitative data sets from the case studies.

- **Chapter Five: Analysis of Research**

  This chapter outlines how the expert focus group was involved in the development and verification of the key capability areas included in the capability maturity framework for infrastructure management resilience. This includes how to develop Capability Maturity Framework. The framework development is presented in this chapter, as the most significant outcome of this study.

- **Chapter Six: Conclusions and Recommendations**

  This assesses if the research objectives are met, lists the study's limitations and constraints and summarises the study, while making recommendations for future research, recommendations to policy makers and recommendation to academia.

1.11 SUMMARY

The phenomenon under inquiry is introduced in this chapter. The use of CMM's to accelerate long-term infrastructure planning and delivery has piqued the world. Category B4 municipalities lack the infrastructure management resilience required to address service delivery challenges. The section explores the problem statement and the significance of the study. Recent capacity models (CMM) have omitted resilience from their design criteria, rendering them unsuitable for Category B4 municipalities. As a result, traditional CMM are unaware of these municipalities' unique capabilities. The study seeks to develop a capability maturity framework for reliable infrastructure management based on the existing capability maturity models (CMM), but with the resilience stage incorporated into the design requirements for usage in Category B4 municipalities.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter continues by introducing the objectives and methods used in the review, to analyse, critique, and synthesize the literature on a study issue, to establish new theoretical viewpoints and framework. The chapter also discussed the key concepts applicable to the study, including service provision, resilience, infrastructure management capabilities in municipalities and project management capability maturity models.

The historical background of service provision and engineering skills in South Africa is given, analysing substantive findings of previous research in the field of capability maturity models, and identifying knowledge gaps demanding further exploration. The chapter also discusses how South African rural municipalities compare to rural municipalities around the world and in Sub-Saharan Africa in terms of engineering skills, infrastructure management, and service provision. Further, the chapter discusses the theoretical applications related to the study and the pertinent body of knowledge to locate the current study. The chapter ends by outlining a process towards resilient employee capabilities that are essential for assessing organisational resilience, premised on the capability maturity theoretical framework. As explained in the section below, there are certain inclusion and exclusion criteria that are appropriate for completing different literature reviews, such as systematic reviews, meta-analyses, and integrative or narrative reviews (Snyders, 2019; Palmatier et al., 2018). The researcher used the integrative process to review literature in this study.

2.2 LITERATURE REVIEW DESCRIBED

Essentially, advances in knowledge must be based on previous work (Johnson, Russo and Schoonenboom, 2017). Scholars can discover where the knowledge frontier on a certain topic is, by reviewing literature to contribute new knowledge (Guthrie, 2021; Denzin and Lincoln, 2018). Palmatier et al. (2018) describe the literature review as a noble way to synthesize research findings to show evidence on a meta-level and to identify areas where more research is needed. According to Snyders (2019), the literature review is an important part of developing theoretical frameworks and conceptual models, synonymous with the objective of this study. Most literature reviews concentrate on the research findings of the literature under consideration, some include

a section on the research methodologies and theories employed in the study (Denzin and Lincoln, 2018).

Literature reviews can be organised in three ways, according to Snyders (2019), (a) thematically by reviewing literature on the same concepts (b) historically, through issues appearing in the literature in a chronological order, or (c) methodologically, by means of a literature review using the same research methodology. In academia, outdated literature reviews are often seen as inadequately detailed and less rigorous, and they are written at random rather than following a methodology (Guthrie, 2021). In a research process, a good and well-conducted literature review, according to Johnson (2017), provides a firm foundation for expanding knowledge and supporting theory foundation. Continuing with the discussion, Snyders (2019) submits that literature reviews provide an inspiration of integrated findings and opinions based on a variety of empirical facts that no single study can contest. Although in the following section the different ways of reviewing literature are detailed, integrative method was chosen for his study.

2.2.1 Systematic Literature Review

Synders (2019) described systematic literature reviews as an approach and process for discovering and critically evaluating relevant research, as well as gathering and analysing data from that research study. Likewise, early research entailed completing a basic systematic investigation to uncover previous work, analysing the literature in the topic, and, if any, confirming whether the findings address the current research problem (Bryman and Bell, 2021). According to Creswell (2018), the researcher needs to find scientific journals and sites where scholars in similar fields of study, communicate research progress, results, methodologies, and contribute knowledge by using systematic reviews. Systematic literature reviews have a strict search strategy and article selection limits (Creswell, 2018). According to Johnson (2017), systematic reviews have proven to be useful at synthesizing many research studies in each field and producing evidence of effect that can be used to guide policy. Only if no systematic review that answered the research questions could be identified would a further systematic review be conducted (Johnson, Russo and Schoonenboom, 2017).

Snyders (2019) predicts that someone new to scientific research, unsure which high-level databases are relevant to their topic, could struggle to conduct systematic reviews. On the other hand, systematic reviews are not always an ideal strategy (Snyders, 2019), particularly when seeking to explore a topical subject that has been viewed and examined from numerous

perspectives, as is the case with this study subject on the dearth of resilient engineering skills (Linnenluecke et al., 2020). Thus, systematic literature review was not solely utilised in reviewing relevant literature in this research.

2.2.2 Meta–Analysis Literature Review

Meta–analysis reviews, according to some academics, are the systematic gathering, synthesis, and analysis of quantitative study findings from several studies on the same issue to reveal patterns, conflicts, or relationships that appear when multiple studies are undertaken on the same subject (Linnenluecke et al., 2020). Synders (2019) views meta-analysis as a way of examining and combining different results that are valid, objective, and scientific.

According to Gilgun (2019), the planning of inclusion and exclusion criteria possibly remain the most crucial aspect of meta-analysis. This form of literature review examines how research in a particular field has grown over time (Creswell, 2018) or how a particular topic has evolved across research traditions (Snyders, 2019). In general, the goal of the review is to find and understand all potentially relevant research traditions that have implications for the topic at hand, and to integrate them, using meta-narratives, rather than effect size measurements (Gilgun, 2019). Before a meta-analysis review can begin, the problem must be identified, the variables must be operationalized, and hypotheses must be generated. A meta-analysis literature review was not relevant in this study because there were no hypotheses to investigate. Meta-analysis remains a rigorous tool for quantitative study synthesis (Gilgun, 2019), nonetheless, except for evaluation scores that measured existing skill levels in Category B4 towns, this study did not contain a large sample of quantitative data, hence it was not used in this study.

2.2.3 Integrative Literature Review

Snyders (2019) describes the integrated review of literature as a type of research that builds on current information to produce new knowledge. Integrative literature reviews are undertaken on issues that are rapidly growing in the literature and have not received a full evaluation and update over a long period of time (Saunders, Lewis, and Thornhill, 2019). This is the reason why the researcher chose to use integrative literature review in this study enquiry, as infrastructure management capability resilience in category B4 municipalities have long been a cause for concern (Lawless, 2015). The South African local government sector is still looking for research studies that could help restore resilient staff infrastructure management capabilities.

The related developments of capability maturity continue to accumulate, and the topic of resilient infrastructure management, as an emerging issue in the field, has become a desirable topic for integrative literature reviews. According to Gilgun (2019), whether the literature review discusses a mature or an emerging subject, the person who reads the review, expects to see the knowledge from the literature merged into a model or conceptual framework that offers a new viewpoint on the subject matter. Cooper and Schindler (2018) mention that integrative reviews are found to be impressive at identifying new and developing themes contributing to the growing body of literature, which may contain conflicts or a disagreement between the literature and observations about the topic that are not addressed in the literature. An integrative review approach continues to be effective when a research subject requires a more creative data collection technique, and the review objective is a combination of viewpoints to design new theoretical models, rather than covering all articles ever published on the topic (Johnson, Russo, and Schoonenboom, 2017).

Integrative reviews, according to Gilgun (2019), are used to analyse, critique, and synthesize the literature on an issue to establish new theoretical viewpoints and frameworks. An integrative literature review process to critique evidence syntheses and summarises previous results within identified target journals and has been found to be in concordance with the purpose and research question for this study. In this study, the researcher employs an abductive approach, firstly through extrapolations from known premises and drawing inspiration from the existing capability maturity models (CMM) to get to the depth of the problem.

This study did not intend to review all publications ever written on the capability maturity models, but use the existing CMM to assess the current capability maturity status of infrastructure management, identify areas of improvement and construct a new framework for Category B4 municipalities. The purpose of this integrative literature review is to evaluate and synthesize the available scholarly research on engineering skills (ES) deficits, infrastructure management resilience in Category B4 municipalities, and identifies capacity improvement areas to close this gap.

The process outlined in Figure 2.1 was followed to review literature related to the study:

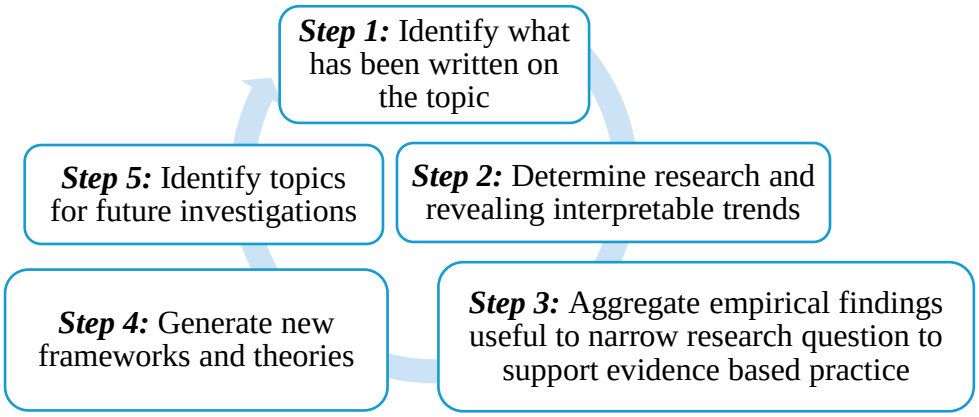


Figure 2.1: Integrative Literature Review Methodology

Source: Literature Mapping Review

Step 1 - Literature Identification

The first step is to understand how to find relevant articles based on the chosen keywords. The literature search started by using the keywords '*engineering skills deficit in South Africa', 'service provision in South African rural municipalities', 'infrastructure management in rural municipalities,' 'capability maturity models', 'resilient infrastructure management capabilities'* and '*capability maturity models in Category B4 municipalities'*. This stage determined which database to search and how to filter data based on inclusion and exclusion criteria (Johnson et al., 2017). Using more precise keywords can improve database search precision, but it may result in missing records (Creswell, 2018). The study then opted for the use of broader keywords, which have allowed the researcher to retrieve comprehensive and inclusive results. The downside was picking up additional irrelevant articles, that were eliminated through the exclusion criteria. The search engines used were '*Google scholar', 'Science direct', 'Web of science'*, and *'Scopus'* databases, which contain scholarly articles from virtually every discipline, with the American Society of Civil Engineers (ASCE) being a popular choice among scholars in the built environment and engineering sector. The review was confined to articles published between 2017 and 2020, in order to focus on recent literature.

Step 2 - Determine Research and Reveal Interpretable Trends

The potential relevant articles were carefully chosen by title and where any of the keywords provided in the title were mentioned, the entire reference was obtained, which included the author,

year, title, and abstract, for additional scrutiny. A total of ninety-four studies related to engineering skills shortages were found after an initial screening of the titles. This section provided insight from the existing body of knowledge synthesis on engineering skills (ES) deficit, infrastructure management (IM), municipal service provision, and methods employed to obtain data to gain insight on what was available in literature. The review was done to see whether there were any trends or if the study findings were consistent. The consistency of these study findings is addressed in depth in the section analysis chapter.

Step 3 - Aggregate Empirical Findings Useful to Narrow Research Question to Support Evidence-Based Practice

Different capability maturity models available in the web-based scientific search engines were reviewed to assess where else these capability maturity models were successfully applied, to improve and optimise service provision. This was done to assess whether the research question could be narrowed to support evidence-based practice. The literature on resilience was the first major topic examined to comprehend numerous delineations and choose the dimension for the current investigation. The literature on resilience was the first major topic examined to comprehend numerous delineations and choose the dimension for the current investigation.

Step 4 - Generate New Frameworks and Theories and to Identify Issues for Future Research

Aghimien, et al. (2021) acknowledge that there were limited studies on the capability maturity models for resilient infrastructure management. Evident from the literature review where some research has been done in Category B4 towns about infrastructure management capabilities maturity, the resilience component has not been applied. Category B4 municipalities are affected by unique capability features, unconsidered by the standard CMM, hence the study intends to include the resilience component in the design parameters (MDB, 2018). No single systematic capability maturity framework for resilient infrastructure management in Category B4 municipalities has evolved. Despite reviewed studies on the engineering skills gap in the construction industry, no recommended systematic capability maturity approach for addressing deficits in infrastructure management and maintaining reliable services in almost collapsed municipalities has been devised. What was not known at a conceptual theoretical level was the capability framework for infrastructure management resilience, developed specifically for rural Category B4 municipalities. The study's main objective was to generate a new appropriate capacity maturity framework for infrastructure management resilience in municipalities with

related skills gaps. So, by tweaking the existing OPM3, the study has introduced the sixth stage of the '*resilience component'*, hoping to make a difference in terms of policy, most probably be useful to the policymakers in changing the ways public infrastructure delivery is implemented.

Step 5 - Identify Topics for Future Investigations

In social research, there is no one optimum method for carrying out research (Creswell, 2018). The researcher's ability to gather, synthesize, and analyse appropriate data for solving engineering skills deficits in rural municipalities in support of the development of a capability maturity framework for the Category B4 municipalities, was critical to the entire research. The integrative review included a thematic analysis of existing literature on service provision and engineering skills deficits, as well as synthesizing of new knowledge on capability maturity models, and related discussions of the conceptual reasoning used for continuous improvement to integrate the concepts and ideas of infrastructure management found in literature. Future researchers are expected to construct a model based on the suggested framework to assist in the establishment of a systematic improvement path for infrastructure management capacities in Category B4 municipalities. The section below offers an empirical examination of literature that covers the history of service provision in South African municipalities, engineering skills shortages, capacity improvement and infrastructure management.

2.3 LOCAL GOVERNMENT AND SERVICE PROVISION HISTORY

Providing essential services necessitates the development of government's critical institutional capacities (COGTA, 2018), while resource adequacy, both financial and engineering skills, remains a prerequisite to reliable service provision (IDMS, 2019). Studies written on this subject were reviewed starting with Brathwaite (2018) on the low-revenue base and Category B4 municipalities' inability to attract and retain highly skilled technical staff to manage infrastructure and provide service. The study argues that despite the constitutional powers granted to municipalities (RSA, 1996) to raise revenue for services provided through both direct and indirect charges, such as rates and service charges, category B4 rural municipalities had been unable to create a viable revenue base due to apartheid constraints on economic development in black communities (Brathwaite, 2018). Furthermore, considering, a restricted local government system of Black Local Authorities had no large revenue base and were hopelessly underfunded, resulting in underserved communities (White Paper on Local Government, 1998). The traditional black authorities still remain responsible for land distribution and infrastructure development,

according to the MDB (2018), despite their limited tax and rates-base generation capabilities, while rural towns were given administrative autonomy as Black Local Authorities, whereas white urban municipalities were relieved of the obligation to provide services in townships through the Bantu Affairs Administration Act of 1971 (MDB, 2018). The Brathwaite's study found that the legacy of weak infrastructure management capacities in rural communities remained a reality due to racist barriers to service provision and limited revenue base. This finding was echoed in subsequent studies (COGTA, 2018; IDMS, 2019; MDB, 2019) that as a result of the new South Africa's local government transition, universal service coverage was introduced, albeit service delivery backlogs remained severe in formerly unserved rural municipalities

Other studies (Lawless, 2015; Palmer et al., 2017; Lawless, 2019) explored a shortage of engineering skills in municipalities as a different issue that impedes service provision and the ability to manage infrastructure. Engineers are instrumental in founding municipalities and providing infrastructure (ACSE, 2017). In South Africa, the lack of engineering skills (ES) has hindered the provision of services, particularly in the rural municipalities (LGSETA, 2018). Throughout the apartheid years, service provision was largely centred in urban metropolitan areas (Lawless, 2015). A hierarchy of technically competent engineers was in place in urban regions to manage infrastructure from planning, procurement, construction, operations, and maintenance (Lawless, 2019). Continuing the discussion of urban regions' abilities to manage infrastructure, Lawless (2015) submits that in metropolitan areas, rates and service bases were extensive enough to fund service provision.

In his writings about the lack of appropriate engineering skills in rural South African municipalities Palmer et.al (2017) highlighted the significance of having a practical framework that allows for the development of infrastructure for functioning rural municipalities. On the same wavelength IDMS (2019) and Brathwaite (2018) in their writings submit that a link between the capabilities of employees and organisational performance exists and that the reliance on external ES had harmed the ability of local governments to manage infrastructure. Whereas, other researchers Conz and Magnani (2019) and Duchek (2019) posit that the perpetual infrastructure management deficit in Category B4 municipalities pointed towards the resilience gap in the current engineering skills support models. None of these studies have proposed a systematic transfer of ES to the existing technical personnel in municipalities during the implementation of engineering support programmes. Since employee capabilities collectively

construct organisational capabilities, however, category B4 municipalities are affected by unique capability features, unconsidered by the standard Capability Maturity Models (CMM), so the study intends to include the resilience component in the design parameters (MDB, 2018). This study seeks to confirm the assumption that a correlation exists between resilient employee capabilities and organisational performance.

2.3.1 Why Engineering Skills are Critical for Infrastructure management throughout project life-cycle

Infrastructure management remains a crucial responsibility to attain cost-effective and long-term infrastructure solutions, given the numerous stages from conception, design, implementation, to maintenance (Lawless, 2015; Brown et al., 2017). Engineering skills support the investigations and identification of community needs, feasibility studies, plans and detailed design, and documentation of the final solution are undertaken, prior to the start of infrastructure projects (IIPSA, 2021). Once the construction of infrastructure projects is completed, continuous operational efficiency, and maintenance must be managed (IIPSA, 2021). Lawless (2015) in her engineering needs and numbers writings, describes the engineering cycle as a process that dictates the support of skilled and experienced engineering teams, not just recently qualified graduates. The capability to manage infrastructure project's planning and design, monitoring, and scheduling, as well as taking the required steps to expedite project activity completion, is essential to projects' sustainability (IIPSA, 2021). Logic says that improving infrastructure cycle procedures requires learning from the past (IDMS, 2019; Flyvbjerg, 2021). Despite this, project management professionals' capacity to meet infrastructure management objectives is seriously hampered by a lack of learning from infrastructure management implementation (Canadian Infrastructure Report, 2019; Hassan and Faris, 2019; IIPSA, 2021).

In South Africa the engineering life cycle was developed primarily to answer the prerequisite for enhanced and sufficient quality infrastructure as well as to mitigate the many issues affecting infrastructure delivery an management (IDMS, 2019).

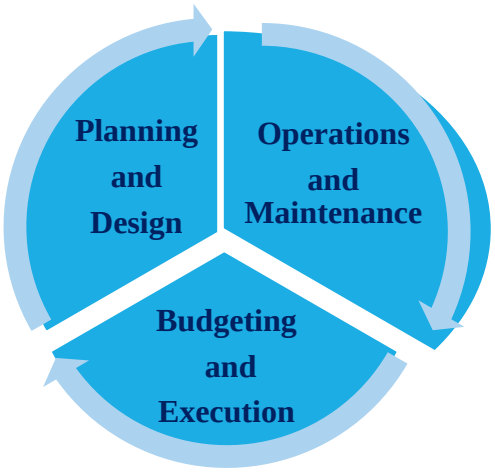


Figure 2.2: The Engineering Lifecycle in Infrastructure Development

Source: Adapted from IDMS (2019)

The engineering life cycle consists of a number of structured processes, tools, and methods for project planning and design, budgeting and execution, and operations and maintenance (IDMS, 2019). The primary goals of the IDMS can be summed up as: setting a baseline by encouraging best practices; fostering improvement in the delivery of infrastructure; addressing engineering skill gaps; establishing a balance in infrastructural roll outs; increasing cost effectiveness; and improving infrastructure planning. The effective application of the engineering cycle, as depicted in the National Treasury Standard for Infrastructure Procurement and Delivery, is essential to the sustainability of managing infrastructure projects (IDMS, 2019; IIPSA, 2021).

2.3.1.1 Planning and Design

Infrastructure planning must be completed on schedule as the first phase of the delivery cycle in order to successfully align the budget cycle with the infrastructure delivery cycle. The municipalities remain with inadequate capabilities in the areas of life-cycle planning and budgeting, construction management, cost management controls and operations and maintenance. Many of the skills and services offered, including site development, rail, waste, water engineering, bridge design, and highway design, are combined in infrastructure design. When it comes to infrastructure delivery, inadequate planning and budgeting frequently lead to slow delivery, inadequate or inappropriate infrastructure, and infrastructure that is not economical, efficient, or effective at meeting organisational objectives. Additionally, it runs the danger of going over the permitted project budgets, wasting scarce resources, or using them inefficiently. Inadequate infrastructure planning and budgeting processes are inevitably connected to failures in effective and efficient infrastructure delivery.

It is true what they say, '*failing to plan is planning to fail.*' Scenario analysis has been proven to be a useful tool for infrastructure planning, according to the National Treasury Standard for Infrastructure Procurement and Delivery (Anon., 2019). Infrastructure planners are required to see how much infrastructure to develop in order to meet consumer expectations for high-quality services, while staying within budget limits set by respective organisations. Infrastructure planning and design engineers, by training, develop long-term supply and demand estimates with a safety factor to account for population growth unpredictability and, more recently, climate change. If demand becomes lower than expected, this strategy may result in infrastructure over-design.

Water planning and design engineers, for example, use reliability, or outage frequency, as a risk-based metric for assessing the performance of water supply systems (DWS, 2019). Many uncertainties impact the water supply infrastructure planning at the same time, including annual reservoir inflows, demographic changes, the price of energy, water supply cost shortages, and climate change, are all factors to consider. Recent methodologies for new infrastructure planning that are resilient to profound uncertainties, such as climate change, have also been developed (DWS, 2019). Early research was centred on adopting adaptive management strategies including catchment reconciliation to allow flexible water supply system operations. In order to maintain resilience in the face of infrastructure condition uncertainties (SACN, 2019), researchers and planners have increasingly investigated strategies to improve resilience and adaptability (ACSE, 2017; Brown, et al., 2017). This study enquiry to develop capability maturity framework for resilient infrastructure management for Category B4 is consistent with the previous strategies.

Experienced design engineers, who were previously employed by municipal governments, have since moved to the private sector (Lawless, 2015; Morgan, et al., 2008). Consequently, the advanced risk and decision analysis methodologies are rare to pull in Category B4 municipalities due to the scarcity of technical skills (SAICE, 2020).

2.3.1.2 Budgeting and Execution

During the execution phase, the uncertainty associated with human performance in the construction of infrastructure projects remains an unavoidable source of risk (SAICE, 2020). Infrastructure implementation issues include risks associated with on-site construction activities (Anon., 2019). Throughout the life cycle of an infrastructure project, it remains imperative to examine and analyze project-specific potential risks that might result in cost overruns and delays

(ICMA, 2020). Once infrastructure has been planned for, the next stage is to make sure it is funded, delivered on time, and kept within the project's budgetary constraints (IDMS, 2019). It must also perform according to plan. One of the biggest barriers to successful infrastructure delivery (meeting time, cost and quality criteria), according to IDMS (2019), is the failure to recognize the budget and time implications of processes that fall outside the actual construction work.

These can include: land acquisition, town planning estalishment processes; urban and spatial design investigation; environmental impact assessments; specialist studies or surveys; construction work permits required in terms of health and safety legislation and timelines or processes associated with water use licences and similar statutory approvals (IDMS, 2019; Kerzner, 2019). All of these obstacles may be handled with enough planning, thus before projects are included in the infrastructure management plan, all barriers must be identified, together with timeframes and budgets for resolution (Kerzner, 2019). According to IIPSA (2021), the underlying value for money is an explicit commitment to ensuring that the most value from the resources available, or the best results from the money spent, are obtained.

Studies that written about the lack of engineering skills in the construction sector and the implication for managing infrastructure projects during execution phase were reviewed to ascertain whether a framework to deal with such is suggested as part of the study findings. Anon (2019) in his study recommended that construction practitioners, such as engineers, construction project managers and contractors, must be able to translate their understanding of the definitions of sustainable construction that support sustainable development into project planning and execution. Whist Lawless (2015) saw deployment of retired engineers in rural municipalities' to provide an excellent training ground for recent graduates in the application of engineering principles and methods as their responsibilities evolve. However, writings by Lephotho and Khatleli (2019) found that there remains no systematic transfer of ES during the implementation of MCPs.

These studies (Lawless, 2019; Anon, 2019; Lephoto and Khatleli, 2019) specifically cover themes amongst others, revenue base to attract and retain skills, deployment of retired engineers to ensure there is requisite capacity to manage infrastructure throughout the infrastructure delivery cycle, and how lack thereof impedes service availability. None of these studies proposed a framework for resilient infrastructure management in the category B4 municipalities.

2.3.1.3 Preventative Maintenance and Reactive Maintenance

Municipalities are expected to uphold their constitutional obligations to provide maintainable, functional, and well-organised municipal services by maintaining infrastructure (SAICE, 2020). According to the literature (COGTA, 2018; MDB, 2019; SAICE, 2020), greater repair of municipal infrastructure will increase service delivery by decreasing system failures, and using better maintenance practices. Conversely, incompetent management of the maintenance of these municipal services is one factor in poor service delivery. Infrastructure deteriorates with time as a result of unstable working conditions, structural fatigue, degradation, wear and tear of turning mechanical systems in water and waste treatment plants, for example, and other problems that vary, depending on the operation (SACN, 2019; SAICE, 2020). Over the infrastructure life cycle, maintenance is a combination of all technical, administrative, and managerial tasks designed to keep it in a good state of repair or restoring it to a state where it can fulfill its intended function (SAICE, 2020).

Maintenance, in its correct meaning, which encompasses any actions pertinent to these issues, is concerned with a system's availability, dependability, and capacity to provide a standard level of quality. Reliability-centred maintenance (RCM) concentrates on developing a systematic, comprehensive maintenance strategy that utilizes the benefits of preventive, predictive, and corrective maintenance procedures to maximize equipment reliability, save costs, and improve service provision (COGTA, 2018). Preventative maintenance is a process that entails periodic checking of equipment to find minor faults and repair them, before they become more serious. Planning periodic inspections, repairs, and replacements, as well as providing management with data on failure reasons, are the goals of maintenance activities. Engineering skills are required to collect new data on infrastructure deterioration, dependability, and breakdown mechanisms, as well as to estimate the impact of failures on performance and costs while taking current infrastructure service demands into account. Municipal city engineers gather financial data on planned and unplanned preventative maintenance operations, such as unit costs of capital and maintenance activities, failure impact, and current equivalent replacement prices.

The requisite capacity to carry out a specific function within a range of performance levels that can relate to strength, speed, efficiency, safety, and responsiveness has implications for engineering decision being taken in managing infrastructure. In other words, engineering decisions and associated actions are necessary to optimize the life of an asset. Engineering choices and operations are necessary to manage the infrastructure. Infrastructure projects

naturally result in the creation of new knowledge, but the Category B4 municipality lacks the infrastructure management framework to draw out the lessons from their project experiences to enable learning from them (COGTA, 2018). The engineering life cycle components of this IDMS framework were later used in this study to identify the capability improvement areas for inclusion in the development of the capablity maturity framework for resilient infrastructure management in the category B4 municipalities. Given the stages outined in the IDMS framework all infrastructure projects inside the organisation should be managed and carried out using the engineering life-cycle framework (IDMS, 2019). Details on the findings and lessons learnt on the lack of consistency in the category B 4 municipalities in using such a framework are presented in the findings chapter.

2.3.2 SOUTH AFRICAN STUDIES WITH FOCUS ON THE LOCAL GOVERNMENT POLITICAL LANDSCAPE AND RESULTANT ENGINEERING SKILLS SHORTAGE IN RURAL MUNICIPALITIES

According to the Local Government Handbook (2019), service provision in South Africa had a long and illustrious history. South African cities and settlements were developed to support the ports, railway routes, mining and farming activities (Lawless, 2015; COGTA, 2018). Infrastructure was built concurrently in mining and agricultural towns, to sustain these towns.

In writings by Mathonsi and Sithole (2015) and Davids (2019) on service delivery disparities in South Africa between rural and urban towns, extended period of discriminatory practices are evident. This was due to the apartheid system in South Africa, which resulted in a racially prejudiced local government structure, with separate administrations for various racial groups (Davids, 2019). According to Mathonsi and Sithole (2015) in the past, the apartheid administration offered exceptional services to a select group of people living in areas where whites predominated. Control over the provision of essential services translated into power for individuals who served conflict-affected areas in South Africa at the time (Mathonsi and Sithole, 2015). Similarly, Davids (2019) concurs that the politicization of local government had consequences for municipal service provision in rural areas.

Lack of infrastructure to provide basic services in rural areas was exacerbated by the Group Areas Act of 1950 (Act 41 of 1950) that imposed tight segregation, based on where people resided and required black people to relocate to areas on the periphery. By separating townships, industrial, and commercial development areas, the Group Areas Act limited permanent dwelling for blacks in urban areas (Group Areas Act, 1950). Likewise, apartheid planners also contributed

to the country's split into basic ethnic groups, permitting the assertion that no dominant group existed (MSA, 1998). Apartheid design imposed urban segregation, and the divide provided a spatial framework for separated services (SACN, 2019). Even though restricted local governments were established in Bantustan homelands - for example, Bophuthatswana, Ciskei, Transkei and Venda, where services were available, these were limited (Wall, 2021). There were no policies in place to encourage basic service provision in rural areas (COGTA, 2018). Another significant disadvantage for black communities was the government's lack of visibility in the black Bantustans. These homeland towns were largely unserved (Wall,2021).

Decades of segregation and apartheid administration had serviced only the white communities, while neglecting service provision for the rest of the South Africans (Palmer et al., 2017). Access to relatively wealthy social groups meant that white local municipalities enjoyed a high degree of fiscal autonomy. With self-funding rates as a base, the apartheid municipalities were fiscally sustainable (MIIF, 2021) but served only a small section of the population (Palmer, 2017). The engineering services department had enough technical staff to handle the whole civil engineering cycle, from planning to design to documentation to construction to operations and maintenance (Lawless, 2015). In the 1980s, apartheid municipalities had civil engineering staff numbers ranging from 2500 to 3000, with a ratio of 20 civil engineers per 100,000 people served (Lawless, 2015). Likewise, young engineers and technicians received on-the-job training under the supervision of more experienced engineers (LGSETA, 2018). The town engineer was the municipality's most senior technical official (Lawless, 2019) and most authoritative figure, in charge of massive infrastructure budgets and assets (COGTA, 2018). Under the guidance of an experienced town engineer, well-structured infrastructure departments managed the full project cycle from planning, design, procurement and to completion, with service provision reliability being the order of the day (SACN, 2019).

Moving ahead of the white supremacy model, all black South Africans belonged to a continuous rural proletariat but were never allowed access to infrastructure-served areas (Davids, 2019). Mathonsi and Sithole (2015) pointed out that those rural areas where black people lived at the time remained underserved. Rural municipalities had been unable to create viable revenue bases because of apartheid constraints on economic development in black communities (MIIF, 2021). As a result, black local governments produced relatively little self-revenue, had ineffective fiscal systems, and lacked the capacity to deliver basic socio-economic services. At the end of the 1980s, municipalities began outsourcing design and construction work stages (COGTA, 2018)

and the brain drain began as design engineers previously employed by local governments moved to the private sector (MDB, 2018). This exodus has proved unproductive, particularly in rural areas that have been left without technical personnel (Lawless, 2019). In the work done by Palmer et al. (2017), it was expected that the legacy of apartheid discrimination would adversely affect engineering skills in rural South African municipalities.

2.3.2.1 Impact of Apartheid Spatial Planning and Urban Segregation on Service Provision

Apartheid was a segregationist regime that once prevailed in South Africa (Group Areas Act, 1950). For centuries, MDA (1998) cities have served as an ultimate symbol of urban division and exclusion. From the late 1940s through to the early 1970s, apartheid shaped planning strategies and mechanisms, like the Group Areas Act were in place. On a city scale, this period was marked by forced removals based on ethnicity and the establishment of new large-scale townships, which continue to dominate the form and structure of many South African cities (Davids, 2019). According to Palmer et al. (2019), rural settlements were surrounded by border industries that were designated for black occupation, since blacks were a valuable supply of labour. Permits were required for economic activities in certain metropolitan areas. The goal of giving permits was to limit operations in cities that employed many Africans (Mathonsi and Sithole, 2015).

Cities with a discriminatory geographical shape had varying levels of infrastructure and services (Davids, 2019) and there were deliberate attempts to curb black urbanisation (MDA, 1998). The apartheid state achieved significant institutional success with its national spatial engineering efforts in support of its ideological goals. The apartheid planning on developing the towns through the creation of infrastructure and the provision of housing was a failure (ICMA, 2020). Writing about building a capable state and service delivery in the post-apartheid South Africa, Palmer et al. (2017), maintain that until there was a systematic development of capacities, the engineering skills gap would wreak havoc on rural municipalities for years to come[1]. In the work done by Mathonsi and Sithole (2015), rural towns never developed into full-fledged municipalities, and they lacked a solid local government structure (MIIF, 2021). In many South African rural municipalities, financial independence was more of a theoretical concept than an existing reality. The towns often only had a superintendent (Lawless, 2007). Many rural populations have relocated to cities, due to a lack of budgets and improvements in service

[1] Palmer, et al.(2017). *Building a Capable State:* Service Delivery Post Apartheid South Africa.

provision in rural communities (MIIF, 2021). The influx control legislation measures, on the other hand, were put in place to stop black migration. (MIIF, 2021). The notion that government involvement was inadequate for communities and irresponsible suggests that black communities were denied basic prerequisites (COGTA, 2018). South Africa had a racially-segregated culture that exclusively benefitted white people.

2.3.2.2 Low Revenue Collection Rates, Inadequate Cost Recovery and Impact on Service Provision

Local governments in South Africa deal with a wide range of issues that impact on service provision. *"This is true to rural municipalities that are on a point of collapse without solid revenue reserves and inability to adequately handle service delivery issues" (National Treasury, 2020).*

Legislative and Regulatory Frameworks for Revenue Collection in South Africa are provided by the government. Local municipalities in South Africa are entitled to a fair portion of the revenue earned by the national or central government, according to Section 152(1) of the country's Constitution (1996). According to this, Section 152 of the South African Constitution, requires that municipalities must establish excellent financial management systems within their budgetary resources (RSA, 1996). This share is given to local government to fulfil its constitutional obligation to provide fundamental services to communities.

The Division of Revenue (DORA) Act, which is reviewed yearly, has an impact on these activities. In order for rural towns to raise money for service delivery, DORA's function as a legal requirement is crucial. Despite this constitutional provision being routinely invoked, non-compliance has the most negative effects on rural municipalities. This occasionally has to do with the wrongdoings of the apartheid system. Many years have passed since the end of apartheid, but opponents (Andreas, 2021; GGA, 2021; IIPSA, 2021) contend that segregated types of development are still common in rural areas because they lack the resources to address previous socio-economic disparities.

The fatal COVID-19 pandemic that had a negative impact on local government operations worldwide, and South Africa has not been exempted from these problems. Compounding the situation is the rating agency, Moody's, downgrading of the nation into junk status, government was unable to help municipal revenue collection in the preceding two years, since many people employed in a variety of sectors either lost their jobs, or were unable to earn any money to be

able to pay municipal rates (National Treasury, 2020). Rural municipalities in South Africa are the hardest hit, due to existing socio-economic inequalities that function as barriers for efficient revenue collection, given the current status of revenue collection obstructions on a national level (Aghimien et al., 2021).

In South Africa, many rural towns rely on surcharges from services, like water and electricity to fund their operations. Due to dissatisfaction with the service offered, some clients fail to pay their monthly utility bills. Low collection rates make it difficult for municipalities to recover adequate costs to operate and maintain infrastructure, and to continue providing a reliable service (COGTA, 2018). Rural municipalities are ill-equipped to properly collect sizable sums of revenue from consumers on an annual basis owing to a lack of skills and dedication, poor performance management, inadequate and inappropriate revenue improvement initiatives, and a lack of execution plans that fail to collect. This often leads to a substantial municipal income shortfall to recruit and attract engineering skills. Remote municipalities' ability to provide services effectively is negatively impacted, when citizens in rural areas fail to pay municipal rates.

Due to the skills gap in rural communities, it is essential that government employees receive continuous education in tax collection procedures. Such skill emancipation initiatives can result in efficient rural service provision and high-quality public infrastructure. According to some academics (Ganiyu and Afolabi, 2021; Aghimien et al., 2021), revenue collection in rural local municipalities can be enhanced by effectively implementing legally mandated tactics of revenue collection, such as metered services, debt and credit management, accurate billing, and replacing broken meters to maintain the provision of services in communities.

2.3.3.3 Legislation Promoting Restructuring and Inclusive Service Provision

The local government sector in South Africa has tried re-equipping itself from apartheid's highly uneven, racially classified local administrations that have been replaced by a potentially integrated, developmental, equitable, and sustainable form of government. The local government restructuring process was made possible largely by the legislative framework. The overarching legislation in South Africa used to bring in the new democratic local government has been the Constitution of the Republic of South Africa Act No. 108 of 1996 (RSA, 1996), the Municipal Demarcation Board Act, the Local Government White Paper (1998) and Municipal System Act (1998). Until the Local Government Transition Act 165 came into effect in 1993, the traditional

authorities performed some local government activities, as black local authorities in the former homelands.

2.3.3.4 Constitution of the Republic of South Africa

Within a multi-sphere government, local government remains an important aspect of South Africa's constitutional system of decentralised administration, which was established following the democratic elections of April 27, 1994, (RSA, 1996). Local government was acknowledged in the Constitution (RSA, 1996) as a crucial institution for the progression of democracy, for the first time in South African history. Referencing Chapter 7 of the Constitution Act 108 of 1996, the South African state chose a strong local government system that has been constitutionalized.

According to Section 152 of the Constitution of the Republic of South Africa RSA (1996), one of the goals of this system of local government, remains the promotion of social and economic development. Municipal autonomy, in its broadest meaning, has been depicted by the constitutional delegation of authorities and functions. Municipalities, as the closest sphere to the people, continue to be at the forefront of service delivery concerns (COGTA, 2018). According to Section 153 RSA (1996), municipalities shall structure and manage their administration, budgeting, and planning procedures in such a way that priority is given to the community's basic requirements and to promote the community's social and economic growth.

2.3.2.5 The White Paper on Local Government

The White Paper on Local Government (Act 27 of 1998) made provision for a new vision of a post-apartheid society expressed in the concept of developmental local government (RSA, 1998). A series of outcomes and several instruments were proposed towards a developmental agenda. The first proposal on the White Paper was the division of the country's area into municipalities, each controlled by a local council elected by the people. The White Paper (1998) inspired municipalities to unite racially segregated group areas under a single local government with single tax base. The idea was that enough revenue would be generated to keep towns as financially viable municipalities (RSA, 1998).

2.3.2.6 Municipal Systems Act

The Municipal Systems Act (Act 32 of 2000) requires all municipalities to prepare an Integrated Development Plan (IDP) to meet the development needs of individuals and communities under their jurisdiction. The MSA (2000) promotes community participation in the identification of

development initiatives as well as fiscally and environmentally sustainable municipal service provision. From 2000 forward, municipalities were expected to place a strong emphasis on integrated planning and service delivery.

According to MSA (2000), the IDP also benefitted the provision of services by acting as a road map for where infrastructure services should be prioritized and implemented to solve apartheid infrastructure backlogs in previously unserved black communities. This was an important piece of legislation to address infrastructure backlogs, however, most rural municipalities never saw IDP's beyond statutory compliance IDMS (2019). According to National Treasury (2018). IDP's should be firmly rooted in municipal decision-making, budget allocation, and infrastructure service operations strategies.

2.3.2.7 Restructuring and Implications for Service Provision

In the South African local government context, the reasonable question to address after the first democratic municipal elections victory against apartheid (GGA, 2021) was *How could restructuring deal with service provision inequalities?* Previously, decisions on service delivery were made by town engineers (Lawless, 2015), but now they are made by executive mayors who are accountable to their political parties. Local government restructuring has led to the collapse rather than the extension of existing municipal engineering divisions, as a substantial number of public sector personnel, including engineers, were offered packages, with some opting for early retirement rather than retrenchment (Lawless, 2019). As part of the restructuring, senior engineers were replaced by young, inexperienced black technicians who were designated as technical directors in local governments to achieve democratic black inclusion objectives (Lawless, 2019).

Many of these young people lacked the necessary experience to drive service provision, yet were unable to advance professionally due to a scarcity of engineers to mentor them (Lawless, 2019). The National Treasury (2018) employment policy constraints that confine staffing costs to one-third of municipal revenue exacerbated the quality of appointees in municipal engineering technical departments. According to Lawless (2015), the criteria remained unattainable, particularly for low-income rural communities in severe need of technical assistance.

2.3.2.8 Service Provision Post-1994

Government, academics, and practitioners in South Africa (MDA, 1998; GGA, 2021) have recognized the need for creative approaches to infrastructure planning in general, and spatial

planning in particular, because of the changing institutional framework for spatial planning. Since 1994, land reform in South Africa has advanced at an incredibly slow rate, hence drastic measures are still required to speed up land reform (GGA, 2021). Apartheid spatial planning continues, even if the democratic government has built almost 4 million homes for the poor, as the majority of black people still reside in townships and go daily into the city for jobs. An estimated 30% of lower income groups' incomes go toward transportation expenses (MDB, 2019). In general, attempts to improve integration and service provision using spatial planning as a tool have resulted in absorbing adjacent rural areas (MDB, 2018). Many of these attempts, including the Reconstruction and Development programme (RDP), found their way into post-apartheid spatial planning legislation and practices.

The RDP was created to alleviate social and urban-rural geographic disparities (RSA, 1996). The RDP, which focused on infrastructure and basic services after 1994, dominated the early years of the democratic government. The RDP coined terminology, such as 'compact cities' and '*concentration and union of the urban fabric*,' which have remained in use ever since. Due to the historical inefficiencies of public service delivery, budgetary restraints, and a lack of engineering resources, the South African public sector started forming public private partnerships (PPPs) to enhance service delivery (Taute, 2021).

Reflecting on the use of PPPs, Taute (2021) observed that co-operative partnerships had put the government in a position to strategically deliver services by utilizing the stakeholder's core competencies and resources to address the failure of the government and maximize the creation of social value. According to GGA (2021), the integration resulted in more equitable, accessible, and cost-effective services. Individuals from all demographics who had previously gone unnoticed were given a chance to be served (DWS, 2019).

2.3.2.9 Service Provision Today and Rise of Service Delivery Unrests

Currently, the South Africa's national government has received much negative feedback about the ability of its local governments to provide basic services (Handbook, 2019). The situation at the municipal level had deteriorated, as people's hopes for better lives are not fulfilled (COGTA, 2018). COGTA (2018) mentioned poor service delivery, inept employees, and technical skill shortages as the main sources of dissatisfaction and mistrust, culminating in nationwide protests. Even though the new government had enhanced access to services, such as housing, water, and electricity, according to Statistics SA (2019), the statistical data has not translated into socio-

economic realities for the majority of South Africans. In the work done by Lawless (2015); COGTA (2018); GGA, (2021); Local Government Handbook, (2019); ICMA, (2020), municipalities were still unable to manage their infrastructure, carry out operations and maintenance, nor calm down irritated ratepayers due to dysfunctional services.

Although the apartheid government sought to make people pay for services in the 1970s, local government was met with fierce opposition through rent boycotts in black townships in the 1980s and early 1990s (ICMA, 2020). In the writings by GGA (2021) during the apartheid era, even though services were still biased along racial lines, the provision of vital essential services was subsidized. In order to remove the culture of non-payment and resistance prevalent in the 1980s, (COGTA, 2018), the new South African government-initiated Operation Masakhane (*'let's build together'*) obliged households to pay for utilities such as water, sewage, electricity, and refuse collection. The establishment of this cost recovery system for service delivery was met with opposition, as it was largely viewed as an imposition on the poor (GGA, 2021).

Likewise, rural municipalities had no significant revenue base (COGTA, 2018). As a result of lack of revenue, according to National Treasury (2018), 113 municipalities passed underfunded budgets in the 2018-2019 fiscal year, making operational spending commitments without identifying revenue sources to fund such commitments. Another consequence has been the municipalities' failure to pay service providers (IDMS, 2019), resulting to a deterioration in the public sector's balance sheet.

The rising service delivery demonstrations are a cause for concern, given the well-known precept in practice literature that '*if local government fails, South Africa fails'* (GGA, 2021). According the GGA (2021), public perception of the provision of basic services has declined from 72% in 2000 to 43% in 2017, fewer South Africans believe that the government is operating well in terms of providing services. The lack of engineering capacity remains the most central impediment facing rural municipalities, in particular (ICMA, 2020). In South Africa recently, on the engineering skills supply side, one engineer serves every 3 200 people compared with other emergent Sub-Saharan countries where the ratio is 1:150 (ACSE, 2017). This situation existed due to a systematic shrinking of organisational capacities, which may need long-term enhancement of high-priority skills (LGSETA, 2018), infrastructure management capabilities being the high priority, in this case study.

In recent years, South Africa's national government has worked to improve the engineering skills and service provision efficiency (LGSETA, 2018). As a result, capacity-building programmes were viewed to address the imbalances in engineering skills in low-capacity municipalities (Handbook, 2019). The goal of deploying engineering support consultants was to rebuild technical departments in outlying municipalities that lacked ES (Rebuild, 2017).

Since 2003, billions of rands have been spent in government capacity-building budgets (Lawless, 2015; National Treasury, 2018; GGA, 2021) on recruiting engineering support consultants in underperforming municipalities, including but not limited to rural municipalities. Project Consolidate is one of the programmes targeted at failing municipalities. However, only a handful of municipalities went on to achieve remarkable achievements and improvement, but some remained locked in a negative spiral of lack of performance, owing to underlying institutional deficiencies, as well as skills and financial management issues, once the support was withdrawn (Palmer et al., 2017). In the previous studies reviewed Palmer et al. (2017); Davids (2019); Wall (2021); Taute (2021) there has been minimal research regarding engineering skills capability maturity models for improved service provision in rural South African municipalities.

2.3.3 EMPLOYEE SKILLS THAT COLLECTIVELY CONSTRUCT ORGANISATIONAL CAPABILITIES

The built-environment bodies, government, and engineering associations have been scrutinizing the poor infrastructure management capacities in Category B4 towns, (SAICE, 2020; LGSETA, 2018; National Treasury 2018; SACN, 2021; ECSA, 2021). Organisations are thought to have a higher chance of delivering successful projects - if they have employees' skills sets and processes in place that represent a mature project management environment, based on a culture of continuous development (PMI, 2021). Observations have been made on how the lack of these capabilities translated to large cost overruns on some key local government sector projects, poor construction quality; whilst too many efforts and resources are being invested in making untimely repair and replacement as newly delivered assets are rapidly deteriorating (SACN, 2021). Even in institutionally deficient environments, infrastructure project management is still relevant. Project management as a standard approach necessitates a certain level of maturity. Institutional problems could be caused by a lack of implementation capacity between municipal employees and stakeholder incompatibility.

In their writings on building a capable state, Palmer et al. (2017) posits that where employee skills were lacking, organisational capabilities to perform were found to be inadequate. Organisations

must develop their understanding of and competencies in project management to be co-ordinated and guided by project implementation of the organisational strategy. Brown et al. (2017) showed that systematic processes for improving employee skills and knowledge have been successfully implemented in ICT organisations. Likewise, organisations that used capacity maturity models were able to map out a path for continuous improvement of key capabilities at various organisational levels (PMI, 2018).

In local government, the systematic, continuous improvement of engineering skills critical to the management of infrastructure portfolios, programmes, and projects, (Palmer et al., 2017) remains an issue that must be solved. Since resilient employee capabilities collectively construct resilient organisational capabilities, Brathwaite (2018) suggests that a link between resilient capabilities of employees and organisational resilient performance exist. This study confirms the assumption that a correlation exists between resilient employee capabilities and organisational performance.

2.3 ENGINEERING SKILLS, INFRASTRUCTURE MANAGEMENT, AND SERVICE PROVISION

The section reviews the state of service provision globally, as well as in Sub-Saharan Africa and finally, how these countries compare to the South African situation. A selection of studies on dysfunctional municipalities are also reviewed.

2.3.1 Global View on Service Provision, Engineering Skills, Management of Infrastructure

The work done by Rebuild (2017) reveals that even the richest countries are still beset with infrastructure management (IM) capacity constraints, while Mensah (2019) argues that poor IM is a common occurrence in many rural towns worldwide. In Canada, the second-largest country in the world, the role of local governments in service provision decision-making and the level of municipal services available to rural communities vary significantly across local authorities within the same region (ICMA, 2020). Likewise, in the United States with their good economy, inadequate maintenance of infrastructure is a struggle that continues to emerge, though with varying degrees across the states (ACSE, 2017). In addition, significant deficiencies in providing and managing rural infrastructure have persisted across Indian states, due to inefficient local level institutions and infrastructure delivery mechanisms (Ghosh, 2017). A widely held view has been

that few governments across the world seem to have the requisite capacity to manage infrastructure (ACSE, 2017).

2.3.1.1 Canada

Canada is the world's second-largest country by land mass, with economic activity in the industrial sphere increasingly concentrated in a few areas. According to the Canadian Infrastructure Report Card (2019), low density residential development on the periphery was a feature of western cities throughout the twentieth century. Similar to the South African urban-rural pull (ICMA, 2020) rural residents had strong ties to the city, primarily through employment. In the 1980s, demographics began to shift as people returned to rural communities due to the economic viability of rural service centres (ICMA, 2020). Preferences for rural living and the consequential sprawling of rural residential developments, had a potential for rapid population turnover in communities (Canadian Infrastructure Report, 2019), and serious implications for service provision, particularly at a municipal level (ICMA, 2020).

Background to Rural Canadian Municipalities

Canadian municipalities own roughly two-thirds of the critical infrastructure assets required for Canada's quality of life (ICMA, 2020). According to the Canadian Infrastructure Report (2019), approximately one-third of the municipal infrastructure remains in a very poor state of repair, due to deferred maintenance backlogs. The report further states that 25% of all public infrastructure was faced with asset planning and formidable maintenance challenges. Many rural municipalities, according to the Canadian Infrastructure Report Card (2019), do not follow the asset management processes for municipal infrastructure, recommended by the federal government.

These rural towns are unable to meet asset management demands due to limitations in the tax base and infrastructure management capabilities (Rebuild, 2017). This Canadian situation is like that of rural municipalities in South Africa, which have no significant revenue base (COGTA, 2018). Likewise, low capacity rural municipalities have been a cause for concern to the central government (Martin et al., 2012). The lack of adequately trained human resources has been the primary, and perhaps the most problematic challenge in rural municipalities (Tomas, 2022). This has resulted in high dependency on consultant's aid for successful municipal asset management (Rebuild, 2017). This traditional ES assistance worsened atomization and resulted in locally

focused solutions that impeded regional collaboration. To date, federal gas tax transfers have been used to help expand infrastructure management capacity in a way that is less state-centric, more bottom-up, and better responsive to changing local conditions (ICMA, 2020).

2.3.1.2 United Kingdom

In the United Kingdom (UK), [England, Scotland, Wales, and Northern Ireland] there is a unitary, single-tier local government system. However, England also has a mixed system of single-tier local government, with unitary authorities (Sandford, 2022), such as the Greater London Municipal region, and metropolitan district councils, and two-tier local government, with county councils. Municipalities were only in charge of delivering housing benefit and council tax relief (RSN, 2021). Even in Northern Ireland, which has its own Parliament and civil service, the policy is to keep Northern Ireland on par with the rest of the UK (Sandford, 2022).

The UK White Paper on Local Government sets out the government acknowledgement of decentralizing institutions as a means of delivering better public services. Mensah (2019) comments that the central government should allow as much freedom as possible to enable governance arrangements to be tailored to local circumstances. The city's competency is measured using capability reviews in the public sector of the United Kingdom (UK). According to the report, this is considered as a way to hold local government accountable for enhancing their ability to deliver municipal services (RSN, 2021).

Background to Rural Municipalities and ES in the United Kingdom

The rural infrastructure dimension in the UK is that rural local governments are more reliant on income from council tax to fund service provision (RSN, 2021). Small towns and rural communities in the UK often have limited local government service delivery and planning capacity (ICMA, 2020). Mensah (2019) argues that most public sector institutions in developing countries are not able to attract and retain a high calibre engineering workforce. According to the Rural Rebuild Coalition in the UK, rural infrastructure remains in a deteriorating state, however, routine maintenance has not been an easy task to accomplish in most financially constrained rural towns (Rebuild, 2017). Past infrastructure initiatives often prioritized urban infrastructure, neglecting the unique requirements of rural communities, yet the global competitiveness of rural areas depends on a robust and reliable infrastructure (RSN, 2021).

2.3.1.3 Sub-Saharan Africa

Service provision in Sub-Saharan Africa continues to be reliant on the ability to inspire and keep unique skills due to a paucity of specialized technical and professional skills (Davids, 2019). There remain variations concerning global SDG targets and national realities (UNICEF, 2017). It is estimated that in Sub-Saharan Africa, 42% of the population lacks access to basic water supplies, while another 72% lacks basic sanitation (GIZ, 2019).

The problems with access to clean water and sanitation in sub-Saharan Africa are mostly of a scientific and technological nature. Comparing Sub-Saharan Africa to other regions of the world, it has a significantly higher percentage of its people without access to clean water, making it the most disadvantaged among developing nations. This is especially true in remote, impoverished rural areas where installing piped water systems is typically not financially viable.

Increased SA country funding and engineering capabilities are required to achieve SDG infrastructure targets for water supply (UNICEF, 2017). In the absence of extensive government assistance and donor funding, most rural, poor, and secluded communities struggle with effective development and management of infrastructure (Van den Berg, 2017). Some countries were deemed relevant, given that they are former British colonies and according to Davids (2019), colonialism played a role in forming and managing these third world countries. These countries are still using a local government system similar to that of South Africa. In developing countries, particularly in Sub-Saharan Africa, there is a lack of both quantity and quality of infrastructure related to service provision (Abdul-Majeed et al., 2018). Nigeria is in a similar situation.

2.3.1.4 Nigeria

The state of Nigeria's infrastructure remains in a poor state of repair, resulting in inadequate municipal service delivery (Abdul-Majeed et al., 2018). In the work done by Ganiyu and Afolabi (2021) on the sustainable infrastructure provision in Nigeria, rural towns are largely underserved in terms of basic infrastructure, compared to large urban centres. Most of these marginalized areas have insufficient and dysfunctional infrastructure services, such as an unreliable water system, sanitation and sewerage facilities, and an unreliable electricity supply (Ganiyu and Afolabi, 2021). More progress is required because only 26% of those living in rural areas have access to safely managed sanitation, while 34% of those living in urban areas have access to safely managed sanitation (Manu et al., 2019). Klaas (2020) concurs that poor municipal infrastructure management practices, increased urbanization, and limited investments in water supply and

sanitation have resulted in the *"three lows*" (low rates of cost recovery, low provision, and ultimately, low service quality) commonly associated with public water services in Nigeria.

The rural local governments in Nigeria have not been able to perform optimally, given the shortage of infrastructure procurement personnel with the necessary technical skills and knowledge for modern procurement management (Manu et al., 2019). According to Ganiyu and Afolabi (2021), Nigeria has recognized the importance of skills in promoting sustainable development and increasing people's capacity to address environmental and development issues. In the work done by Ganiyu and Afolabi (2021), the need to address major skills shortages in public sector professionals participating in municipal infrastructure procurement across the project life cycle, from initiation to operations and maintenance phases, had been raised, particularly at the lower levels of government.

In the past, the Nigerian government developed policies as embodied in various National Development and Rolling Plans to expand infrastructure services to all segments of human settlements; however, Manu (2019) argues that these efforts have yet to achieve the desired goals [sustainable provision and maintenance of infrastructure]. Nigeria has recognized the importance of skills and the need to hire professionals - such as engineers, local bricklayers, and local plumbers as the first step in ensuring the functionality of infrastructure services, increasing people's capacity to address environmental and development issues (Ganiyu and Afolabi, 2021). Nigeria, like South Africa, has a three-tiered government, but the difference is that all revenue collected in Nigeria is held in a federal account before being distributed to the three tiers of government (Ganiyu and Afolabi, 2021). The culture of not maintaining infrastructure has been a major nuisance confronting local government service delivery in Nigeria (Manu, 2019).

2.3.1.5 Uganda

Due to low service coverage and poor operational efficiency in most towns, the Ugandan government commissioned a study for urban water subsector reform in 1998, with the goal of achieving universal service coverage, long-term service delivery sustainability, and affordability for the poor, while considering water as a social and economic good. The urban municipalities in Uganda are distinguished from rural areas by a greater likelihood of having an improved on-plot water supply, payment for water services on a regular basis, relying on a shared sanitation facility, and using pit emptying services.

This spectrum of characteristics across the rural–urban transition zone has implications for planning and resource allocation, as well as indicating a need for more integrated service models suitable for the diverse and dynamic environment of small towns. The challenge for water sector managers and professionals remains the provision of adequate services to the currently unserved population, while also being able to meet the demand for projected population growth (Marks et al., 2020). In the case of Uganda, water services infrastructure in Ugandan cities is well managed by the National Water and Sewerage Corporation (NWSC), and good service levels maintained by a highly competent staff complement (Sansom, 2018).

2.3.1.6 ***South African Literature on Municipal Infrastructure***

The dearth of technical skills in rural areas has a long history (Local Government Handbook 2019), as service provision in municipalities were largely concentrated in urban areas during apartheid South Africa (COGTA, 2018). Service provision was non-existent in rural peripheral areas because of racial segregation and exclusion from the mainstream economy (Handbook, 2019). Apartheid was already a significant aspect of local government when it was created in 1948, according to the White Paper on Local Government (1998) in Davids (2019). The failure of local government to overcome the apartheid legacy in terms of service delivery has culminated in an institutional crisis in rural municipalities evidenced by a shortage of qualified employees, particularly in technical positions, as well as deficient financial management systems. The government has chosen to increase rural infrastructure to bridge the rural infrastructure divide wherever possible (IIPSA, 2021).

Various South African studies (TRI, 2017; Ntliziywana, 2017; Tshishonga, 2019) in the built environment that used different qualitative research approaches have been considered. Tshishonga (2019), in evaluating the Siyenza Manje technical support programme, found fundamental challenges in transferring engineering skills (ES) to young candidate professionals (YPs). The Siyenza Manje programme deployed technical experts to coach, supervise, and transfer skills to the YPs, through structured workplace exposure to gain requisite skills and hands-on experience over three years, to qualify for South African Engineering Council (ECSA) registration. An evaluative, descriptive qualitative approach was undertaken using multiple case studies, with a particular interest in the retention levels of graduate YPs, considering the technical skills challenges facing municipalities.

The study found that the Siyenza Manje ES transfer programme has not yielded the desired results, due to limited significant engineering activities taking place within municipalities occasioned by lack of capacity and expertise in the municipalities (Tshishonga, 2019). These findings and the gaps discovered induced this study to assume that previous ES support programmes to improve infrastructure management (IM) capabilities in Category B4 municipalities, were not effective or rather lacked the resilience component. Therefore, the aim of this study is to introduce the resilience concept in the capability framework towards addressing the current ES deficiencies.

One study, undertaken by Ntliziwayana (2017), investigated professionalization as the tonic for municipal dysfunction and used a desktop analytical method and secondary data. The study found that the Constitutional principles of professionalism, together with local government legislative frameworks outlining requisite competency standards to ensure that municipalities deliver on their functions, were not being enforced. The study further recommended that part of the solution to deal with service delivery challenges is the staffing of municipalities with a competent workforce, and enforcement of competency standards to counteract cronyism and nepotism in the appointment of municipal officials (Ntliziywana, 2017). Although there is consistency in the study findings, however, the study recommendations are vague in delineating the '*how'* process to enforce competency standards, to sustain service provision normalcy.

The study by Lephotho and Khatleli (2020) on the efficacy of expatriate professional engineering skills (ES) transfer to candidate engineers in South African mega construction projects (MCPs) was considered. Using mixed method methods, this study found that there is no systematic transfer of ES during the implementation of MCPs. These findings further brought about this study's assumption that previous ES support programmes to improve infrastructure management capabilities lacked the resilience component. Likewise, Njikelana (2016) critically assessed the efficacy of the Provincial Government intervention in dysfunctional municipalities, most of which were Category B4's.

The study employed a qualitative approach to assessing the effectiveness of Section 139 of the Constitution as a viable instrument to deal with dysfunctional municipalities, as opposed to Section 154 which advocates for strengthening and supporting municipalities. Njikelana (2016) contends that these regulatory-support instruments were not achieving their objectives. Confirming these study findings are the trends wherein municipalities remain dysfunctional

despite provincial interventions invoked through Section 139 or support programmes through Section 154 of the Constitution (COGTA, 2018).

Scheepers (2015) in turn assumed a non-positivist explanatory study to design a municipal institutional capacity model, to measure the human and fiscal management as the key capacity elements in municipalities. The study was validated externally through the expert verification workshop, a methodical approach consistent with the methodology used for this study, wherein the expert focus group was involved in the development and verification of the proposed capability areas to be included in the capability maturity framework for infrastructure management resilience.

The findings of several studies support the literature's assertion that cities are desperate for engineering capacity resilience reclamation efforts. Despite the consistency in the proposed methods for this problem and the data collection methods used in previous studies, strikingly, none of the interventions relate to developing an empirical capability framework to improve resilience in infrastructure management capabilities for Category B4 municipalities.

2.3.2 Standardisation of Project Management

A standardized project management methodology is represented by the Project Management Body of Knowledge (PMBOK). It is a body of knowledge made up of tried-and-true methods that may be used in a range of fields. It is the methodical application of strategies, tactics, procedures, and rules by participants in a certain field. The PMI (2021) standards committee identified the nine knowledge domains as a collection of competences and skills required to consistently enhance project management capabilities in the Project Management Body of Knowledge (PMBOK). It provides a platform that aids businesses in developing the methodology, regulations, and phases of the project life cycle required for project management practice. Whether or not the PMBOK includes these guidelines, its focus is on applying the core principles of project management.

Project managers should be more concerned with creating the organisational discipline to adhere to those processes than they should be with deciding which common-sense measures to take (PMI, 2021). The project management standard identifies the procedures that are regularly regarded as acceptable practices and cover a range of projects. Although standard procedures are used, there must be flexibility to allow for expansion and the creation of suitable procedures, as needed. The primary focus of the repetitive processes is to impress the use of self-restraint in

deploying common project management practices. The knowledge domains are employed in this study's context to compare common project management techniques in managing infrastructure between previously deployed support engineers and the on-hand technical staff in Category B4 municipalities.

2.4 RESEARCH CONTEXT ON RESILIENCE

The resilience concept has been used to measure and compare the strength of materials in the construction of Royal Navy battleships for decades (Conz and Magnani, 2019). Over time, from materials science, eco-systems studies, communities, organisations and even nations, the term '*resilience*' has evolved into a concept widely utilized by policymakers, practitioners, and academics (Andreas, 2021). Before Tredgold's (1818) work (quoted in TRI, 2017), the term '*resilience*' had never been used in scholarly articles to characterise wood attributes or to explain why particular wood types could withstand abrupt and heavy forces without breaking. Scholarly work began with its Latin root *(resilire*) and then expanded to symbolize the term's many applications (TRI, 2017). The Global CEO Survey (2021) defined resilience as the system's ability to absorb, withstand, recuperate, and reorganise the situation in the wake of disturbance whilst continuing to function normally. Resilience was commonly used in conjunction with the concept of security to define a feature of materials, ecosystems, communities, organisations, and even governments (Conz and Magnani, 2019). The resilience concept, according to the Resilience Alliance (2017), was a worldwide discourse that had increasingly been applied in several government, business, and management studies. The application of the resilience concept in different sectors.

2.4.1 Use of Resilience Concept in Government

Governments that incorporate resilience into their delivery plans do so in the context of both short-term crises and long-term sustainability, with the primary goal of bringing people and their needs closer together in a more cost-effective and stress-free manner (Brown, Seville and Vargo, 2017). The United Kingdom's civil contingencies law, philosophy, and plans have all been revised to include the concept of resilience (Andreas, 2021). Likewise, South Africa has responded with a multitude of solutions, frameworks, and capacity-building programmes aimed at improving the resilience of government departments (Duchek, 2019). The objective of the South African Cities Network (SACN, 2021) is to discover and enable city policymakers to learn

from cities in general, particularly about local government resilience. Despite the numerous SACN initiatives on water, energy and climate resilience in South African cities, no single systematic capability maturity framework for resilient infrastructure management in Category B 4 municipalities has evolved (SACN, 2021).

2.4.2 Usage of the Resilience Concept in Business and Management Studies

Despite its lack of clarity, the concept of resilience has been valuable for understanding ecosystem behaviour and improving ecosystem management (Brathwaite, 2018). Academic networks and organisations, such as the Resilience Alliance, and the Stockholm Resilience Centre work together to improve ecosystem management practices and long-term sustainability by expanding our understanding of complex social-ecological systems and creating new ideas and solutions (Resilience Alliance, 2017). A resilience approach assumes an uncertain and complex natural-resource setting and strives to produce environmental advantages linked to human well-being over the long term. In business management, the need for resilience is particularly important for organisations providing utilities and transportation and those operating in the financial sector (Brown et al., 2017).

2.4.3 Justification of Resilience in this study

The need to fill up gaps in the body of knowledge in the field of resilient infrastructure management has piqued the interest of academics (Andreas, 2021; ACSE, 2017; Brown, Seville and Vargo, 2017; Conz and Magnani, 2019). The concept of resilience was settled in this study for a variety of reasons, the first of which was to provide a viable alternative to municipalities' continued reliance on external ES support for infrastructure management (ACSE, 2017). Although capacity-building support programmes were seen to bridge ES skills gaps in low-capacity communities, findings from the reviewed literature (National Treasury, 2018; Conz and Magnani, 2019; ICMA, 2020; Lephoto and Khatleli, 2020) concluded that previous ES support programmes were either ineffective or lacked the resilience component.

The study adopted the Global CEO (2021) survey resilience criteria, due to its distinctive, advanced qualities, such as composite organisational abilities and procedures. As a result, the resilience characteristics identified by the Global CEO Survey (2021) are lacking in Category B4 municipalities, as these towns are unable to survive, adapt, and continue to provide reliable services after ES support is withdrawn. The Water Research Commission (WRC) submits that any support model should include verification and follow-up stages (WRC, 2019).

Andreas (2021) submits that strategies and models for improving competence must be grounded in organisational realities. The reality, according to Mirti (2018), is that there were clear technical shortcomings in the beneficiary municipalities as soon as the ES support was terminated. According to Andreas (2021), a resilience concern was the lack of maturity in organisational project management competencies. Since resilient employee capabilities collectively construct resilient organisational capabilities, Brathwaite (2018) suggests that a link between resilient capabilities of employees and organisational resilient performance exist.

This study confirms the assumption that a correlation exists between resilient employee capabilities and organisational performance. Resilience is a rapidly developing field of study with substantial policy implications for long-term development. Employee adaptability is therefore key in assessing organisational resilience and the resilience of the employees upon which the organisation is dependent (Hillmann and Guenther, 2021). Brathwaite (2018) earlier claimed that to maintain resilient competitive advantage, organisations must aim to cultivate specific employee capabilities in the medium to long-term. In a nutshell, the study claims that a significant investment in employee capabilities could improve resilience (ISO 9004 Guidelines for Performance Improvement).

2.4.4 Resilient Capabilities: A Critical View

Critical views argue against numerous drawbacks that have rendered Category B4 municipalities unable to perform their powers and functions with resilience. A purposeful shift towards infrastructure management capability resilience has been an Achilles heel for many South African municipalities (MDB, 2018). This situation necessitates a shift from former unsuccessful ES improvement approaches as argued in some studies (e.g., Ngomane, 2018; Lephoto and Khatleli, 2019) to more novel methods as suggested in Mirti (2018). Critics argue for a fundamental transformation in infrastructure management, primarily by municipalities in Category B4 that lack the necessary technical skills (Ngomane, 2018).

There are numerous claims in the literature that Category B4 municipalities in South Africa lack the capacity to oversee and implement infrastructure projects. Similarly, given the apparent engineering skills gap, an emerging framework for resilient infrastructure management by municipalities in the B4 category, remains critical for maximizing the value of municipal infrastructure investments (Palmer et al, 2017; Ngomane, 2018).

2.5 ASSUMPTIONS

In the literature syntheses from most relevant articles on previous ES support programmes, in the local government sector and construction industry, this study made the following assumptions:

- Previous support initiatives to deploy professional support engineers to improve IM and service provision, omitted resilience, as part of the support model;
- Assumption was that a causal relationship exists between employee IM capability maturity that collectively sustains organisational infrastructure management resilient capabilities. The assumption is that the more mature an organisation is, the more likely the management of infrastructure is to be sustainable with improved project performance. Generally, capabilities are measured in dimensions. If capabilities are improved, it should improve project performance; and
- Resilient capabilities are indispensable for improving capital expenditure and management of infrastructure in the Category B4 municipalities.

2.6 CAPABILITY THEORY

According to Van der Walt (2020), theoretical frameworks in research serve as a foundation for the study and to systematically identify logical relationships between study variables. As a city's most precious asset, Brathwaite (2018) posits that human potential should be sought out and nurtured to develop its capabilities.

Proven by conceptual models, effective resilience management may be built on several approaches that strengthen both organisational and human capacities (Andreas, 2021). According to Brown (2017), if an organisation focused on and capitalized on resilience, its resilience skills should increase over time, shifting from a low-end reactive to a high-end adaptive maturity level. What is not known at a conceptual theoretical level was the capability framework for infrastructure management resilience, developed specifically for rural Category B4 municipalities. The study submits that this is a gap in the existing body of knowledge. This study uses the capacity maturity framework to examine the resilience capability domains of service provision and local government engineering skills to increase infrastructure management capabilities in Category B4 municipalities.

There are quite a few theories that can be applied to organisational capability. Various theories linked to this study were reviewed to identify the most suitable theoretical framework; including Argyris Maturation Theory, Design Theory, Capability Maturity Theory and Organisational learning theory and are explained in detail below in Table 3.1.

Table 3.1 Comparison between Theories

Theory	Main Tenets	Applicability to Research	Weaknesses in Study Applicability
Agryris Maturation	Transition from an immature state to that of maturity and independence	Method on how to transition from an immature person lacking confidence and self-control to a mature independent and self regulated person	Inability to tailor the improvement efforts to the goals and objectives to the orgnaisation under study
	Continued employee competency upgrade		
Design Theory	Maintains active application of maturity improvement models	Enables organisation to recruit and retain desire skills to develop software	Fixated improvement strategies on people, process and technology
	Theoretical perspective on improvement		
Capability Maturity Theory	Promote scalability and evaluate current project management procedures and project performance	Highly advanced model in the project management field	Theoretical assumptions not convincingly elaborate
	Promotion of systematic processes for employee skills and knowledge processes	Tool to assess and standardise rigidity of project management capability measure	
Organisational Learning Theory	Organisations ought to continuously build new potential capabilities via learning and skill acquisition to have a competitive edge	When employees encounter new challenges, they seek out solutions, which often leads to new learning	The focus is on the foundations of existing knowledge and its adaptation with fresh notions to accomplish desired results. This is the theoretical foundation used to conceptualize the evolutionary capability stages and a path to maturity
	Organizational learning is often driven by the need to solve problems or to improve performance.	Organisation's adaptive approach to learning commendable	

Source: Author

2.6.1 Maturity-Immaturity Management Theory

Maturation theory and employee capability improvement require management to provide skills development opportunities so that employees progress from a stage of immaturity and dependence to a state of maturity and independence (Argyris, 1973). In his theory, Argyris (1973) likened the immaturity/maturity continuum to the same way in which infants mature as they approach adulthood.

According to Argyris (1973), individuals mature when a continuum of changes occurs, from being dependent to independent, shallow interest to a strong interest and from passivity to activity and from having a transitory perspective to a long-lasting perspective (Argyris, 1973). In this maturation theory, maturity is characterized by enthusiasm, independence, self-confidence, and self-control. On the contrary, immaturity is associated with inactiveness, dependence, low confidence levels and no strength of will.

The ISO 9004 (2018) guidelines posit that capability maturity in organisations should be characterized by a continued employee competency upgrade and constant skills improvement. Although not delving deeply in this theory, it could be argued that the Category B4 municipalities' dependency on the engineering support programmes and the anticipated independence upon improving engineering skills (ES), resilience, denotes Argyris' dependent-independent continuum. This theory was unsuitable for the study due to its inability to match the improvement effort to the objectives of the organisation under consideration.

2.6.2 Design Theory

Theories in design science prescribe a concrete design methodology, design modelling, as well as offer explanations for the design elements and attributes, for the purpose of achieving a goal (Markus et al., 2021). CMM originated out of the quest by ICT organisations to promote systematic processes for employee skills and knowledge improvement (Linnenluecke, 2017). The Software Engineering Institute (SEI) research, which looked at the skills of software engineers in the middle of the 1980s, is where the CMM had its origins. Likewise, SEI (2021) maintains that active application of maturity improvement models, enabled these organisations to recruit and retain the desired skills to develop high-quality software and to respond to the moving technology age (Kostalova & McGrath, 2021).

This CMM progression route from an *ad hoc*, immature process to a disciplined, mature process with enhanced quality and effectiveness, provides an evolutionary framework for organisational processes. At each stage of maturity, the process areas establish a connected chain of procedures that transform the organisation's ability to manage its employees. Process areas define the competencies that must be institutionalised in order to achieve maturity. To that end, CMM in software engineering organisations fixated their improvement strategies on three areas, which are people, process, and technology.

Figure 2.3: Capability Improvement Focal Components
(Source: SEI, 2021)

According to SEI (2021), CMM implementation by software engineering organisations led to high performance in terms of management optimization. Although the researcher did not accept the design theory in its entirety, the framework design was informed by Markus et al. (2021)'s prescription paradigm of design science. Even though the theory encouraged improvements by focusing on processes, technology and people, the maturity element was not incorporated and therefore found inapplicable to this study.

2.6.3 Project Management Capability Maturity

The term '*project management maturity'* (PMM) has reference to the method, strategy, and decision-making process that has been gradually developed across the entire organisation (PMI, 2021). Organisations apply PMM as a tool to assess and standardise the rigidity of their project management capability. Each organisation will require a different level of maturity depending on its unique demands, goals, strategies, and resource availability (Aghimien et al., 2021). Once organisations start to implement standard project management methodology, and they achieve success with it, they can begin to use this methodology more consistently (PMI, 2021). As a result, their personnel will be able to grow more confident in their processes. This will enhance both the project team member's PM knowledge and maturity of the methodology (Aghimien et al, 2021).

The performance of project management within organisations must be continuously improved. Kerzner (2019) explains how increasing maturity levels logically link to higher formalization of project management because the lower project management maturity levels are considered informal in some project management maturity models (PMMM). A different approach would be to use project management maturity indicators to accomplish the project-influencing factors. Organisations need to be aware of the limits of their project management capabilities. The project management maturity model offers a model of progressive improvement in project management systems and processes, and a roadmap for improvement. One of the main advantages of employing the project management maturity model is to promote scalability and evaluate current project management procedures and measure project performance.

2.6.3.1 Organisational Project Management Maturity Model (OPM3)

OPM3 maturity model is the fourth theoretical concept equally significant to this research. OPM3 is the most prominent maturity model in project and construction management (PMI,

2021) and one of the techniques used to assess project management maturity levels. The organisational project management maturity model, as described by PMI (2021), is based on the management of portfolios, programmes, and projects with the goal of accomplishing service provision objectives. This allows the freedom to tailor the improvement effort to the objectives and goals of the organisation.

Kerzner (2019) argues that the development of OPM3 competencies and the adoption of the associated best practices are meant to aid an organisation in delivering the intended strategic outcomes in a consistent, controlled, and sustainable way. Most multi-methods follow the CMM approach and have a 5-stage continuum. OPM3 establishes and encourages a vital connection between strategy and organisation performance. The model, which is also the most resource intensive, is regarded as a highly advanced maturity model in the project management field. Details on how the OPM3 model is used to assess maturity is provided in chapter 3.

2.6.4 Organisational Learning Theory

This study employed Organisational Learning Theory as the theoretical foundation to conceptualize the evolutionary capability stages and a path to maturity. Inspired by Senge' work in the 1990's that centres around the foundations of existing knowledge and modifying it with novel concepts to achieve desired outcomes. Sari (2022) maintain that Senge's adaptive approach to organisational learning originated in the field of business and a precursor to other sectors including education. This organizational learning theory serves as a basis for determining the essential organizational capabilities required to get a competitive edge in an evolving marketplace environment (Basten and Haamann, 2018). This kind of learning is particularly salient to organizations seeking continuous improvement, which was the case with the category B4 municipalities under investigation. The theoretical focus is on the learning process that enables the organisation to continuously grow and advance in response to changing conditions and needs (Basten & Haamann, 2018).

Senge's organizational learning theory is founded on the following key tenets:

a) Organisations ought to continuously build new potential capabilities via learning and skill acquisition to have a competitive edge
b) Organizational learning is often driven by the need to solve problems or to improve performance

c) When employees encounter new challenges, they seek out solutions, which often leads new to learning.

Thus, the presence of any one of these conditions creates the potential for a capability resilience problem. Hence this study claimed that a continuous capability improvement pathway towards resilience, is required in managing infrastructure in category B4 municipalities. As the infrastructure management capabilities progressively mature, so do the capability improvement areas collectively contribute towards resilience.

2.7 SUMMARY

This chapter reviewed different capability maturity models found in web-based scientific search engines to determine where else similar capability maturity models have been successfully implemented to improve and optimize service provision. The literature on resilience was the first significant issue investigated in order to understand various delineations and select the dimension for the current inquiry. This was done to grasp the research question so that evidence-based practice could be supported. The chapter also provided information from the existing body of knowledge synthesis on engineering skills (ES) deficit, infrastructure management (IM), municipal service provision, and methodologies used to acquire data to gain insight on what was accessible in literature. The review was carried out to determine whether there were any trends, or if the study results were consistent. The next chapter details the conceptual and theoretical framework used for the study.

CHAPTER 3: CONCEPTUAL FRAMEWORK DESIGN FOR RESILIENT IM IN CATEGORY B4 MUNICIPALITIES

3.1 Introduction

The researcher uses a bottom-up generative approach that focused on gaining information on existing maturity models leading to the modification of the OPM3 maturity model (PMI, 2017). Since the OPM3 model is based on the PMBOK, it has a strong theoretical foundation to assess organisational maturity at all levels. For sectors that aim to raise their organisational maturity, OPM3 is designed to assist them in identifying the precise capabilities required to fulfil their goals in reference to best practices. The conceptual framework for this study enables the prioritizing of those infrastructure management capabilities that need to be strengthened to advance through the maturity stages based on the ten knowledge management areas of project management. The researcher followed an abductive process to modify the existing model, starting with a set of observations about the elements of the existing OPM3 model and progressed from those observations to broader generalizations about those observations. The data was then used to recognize early patterns on several OPM3 levels to guide the investigation, and identify common themes that were used to explain and develop the municipalities' infrastructure management capability development levels.

Once the observations were translated into broader generalizations of context, the researcher analysed the similarities and differences between contexts and judged the extent to which the study results are transferrable to the environment - in this case, the B4 category municipalities. Thus, by modifying the existing model, actors were able to interactively construct reality using the observations from the OPM3 model wherein the '*resilience gap'* was imminent. The organisation's infrastructure management competencies are evaluated as they progress through the five levels of maturity.

3.1 1 Level 1: Mapping of PMBOK Knowledge Areas

Organisations at the Initial Level of maturity typically struggle to retain talented employees who are representative of the Category B4 municipalities in this study. Despite the importance of technical expertise, personnel procedures in low-maturity organisations are sometimes ad hoc and inconsistent. In order to circumvent the inconsistencies and *ad hoc* recruitment of personnel in the municipal technical department, the PMBOK project management knowledge areas are considered appropriate to observe and to make broader generalizations on capabilities required

to manage infrastructure in Category B4 municipalities. Because the framework was based on the PMBOK, it has a solid theoretical foundation to assess the organisational maturity at all levels. This PMBOK template ensures that the maturity is portrayed, from insufficient Project Management (PM) realisation to the more organised level needed to support infrastructure projects. This maturity model's primary goal is to assist businesses in focusing on improving project management in harmony with the organisation's vision (PMI, 2021). OPM3 is intended to help businesses determine the precise capabilities.

3.1.2 Level 2: Repeatable Level

The municipalities missed the opportunities to standardize workforce operations, because the common knowledge and abilities required to carry out its infrastructure management have not been established. Noticeably, lessons learnt from previous deployed technical engineers in managing infrastructure are seemingly disregarded upon the termination of the engineering support contracts in Category B4 municipalities. The primary focus of this '*Repeatable level'* was to impress self-restraint in deploying common project management practices (SEI, 2021).

3.1.3 Level 3: Defined Level

The fundamental goal of the defined level is to help a company to acquire competitive advantage through the acquisition of the variety of capabilities that must be incorporated in its employees in order to carry out its commercial activities. The personnel capabilities are an important pillar that support the company strategy and their absence thereof creates a significant threat to strategic business objectives. Improved workforce practices established at this maturity level become essential enablers of corporate strategy by linking capabilities to current and future business objectives. At this level, sessions with stakeholders and experts in the municipal engineering and built environment sector (SAICE and SACPCMP) were held to identify, generalize, refine and, as part of the capability maturity framework, standardize the capabilities, patterns and essential areas for improvement (SEI, 2021).

3.1.4 Level 4: Achieved Level

At this level, the workforce capabilities framework helps an organisation to make more efficient use of its personnel's capabilities. Maturity is characterized by systematic, organisational-wide improvement on scenario planning analysis and process improvement according to the infrastructure management plan. This maturity level was about workgroup activities designed

around the imparting of skills in infrastructure delivery management as well as stringency in documented processes for systematically and efficiently managing infrastructure contract development till execution. At the achieved maturity level, capital and integrated infrastructure planning and investment is integrated across three levels of government.

3.1.5 Level 5: Optimizing Level

Applying the OPM3 organisational project management capability process, the municipalities hopefully continue the improvement path. Maturity level 5 focused on incremental and innovative process and technical enhancements to continuously improve the efficiency of processes. Quality and process performance targets are developed for the organisation, regularly changed to reflect changing organisational performance, and utilised as criteria for managing process improvement. Municipalities' concerns with overall organizational performance from the data collected from multiple projects was discussed at this level. During data analysis, gaps in performance were identified. These gaps were then included as part of the critical areas of improvement in developing the capability maturity framework in Chapter 6.

3.1.6 Level 6: (Resilience Level) Current Study Contribution to Academia

The local government sector has always been on the lookout for research studies that will help with reclaiming resilient employee infrastructure management skills. The research assumes a pragmatist approach and is exploratory. The study contribution to academia was to close the resilient infrastructure management skills gap, particularly in the B4 municipal category, by effecting the six-level of resilience in the existing Organizational Project Management (OPM3).

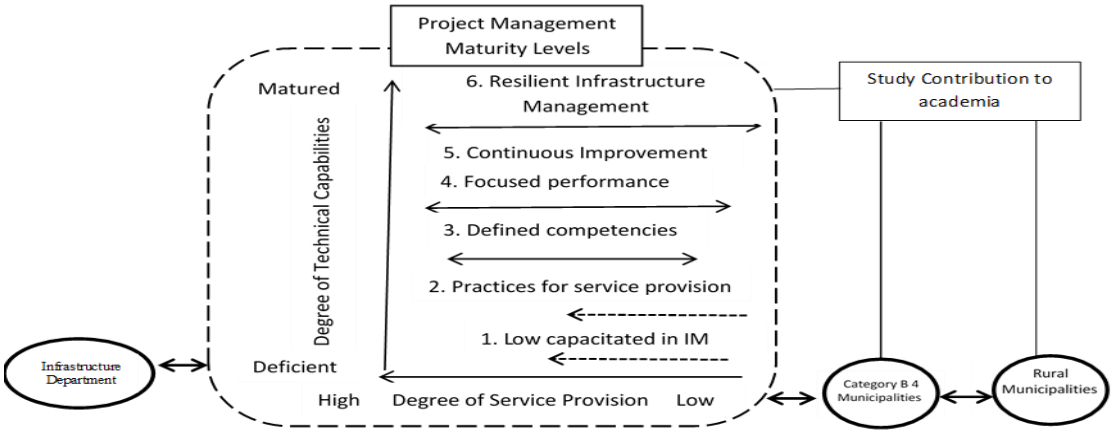


Figure 2.4: Study Conceptual Framework

Source: Author

In this study, a set of observations made from level one through to level five of the existing OPM3 model are used to develop knowledge and broaden generalizations to build a theory, as conceptualized. It is based on the PMBOK and compares organisational actions to a number of established best practices. This is accomplished by evaluating capabilities and associated accomplishments in order to measure best practices in project environments. Given that the model is built on the PMBOK, it has a strong theoretical foundation and can evaluate organisational maturity at all levels. This PMBOK template ensures that the maturity is depicted, from their insufficient Project Management (PM) realization to a more organised level required to support infrastructure projects, while maintaining quality standards.

The sole purpose of this maturity model is to help organisations focus on improving project management in alignment with the organisation's vision (PMI, 2021). OPM3 is designed to assist organisations identify the precise capabilities necessary to meet their goals in relation to quality standards - if they wish to increase their organisational maturity. Additionally, the concept offers a sequential procedure that will promote effectiveness and - ultimately, resilience. Teece (2018) argues that a theoretical framework in research design is vital to measure employee-level capabilities' salience to organisational performance.

In this study, the maturity model offers a framework to assist municipalities in improving their capacity to deliver and manage infrastructure projects according to the intended technical performance, on schedule, and within budget (PMI, 2021). These capability maturity models, outlined in Table 1.2, exhibits design parameters that are inclined to an organisation's determination to improve its employee infrastructure management capabilities. Kerzner (2019) posits that the Capacity Maturity Model (CMM) is founded on the concept that capability improvement is a steady and ongoing process. CMM is centred on an ongoing improvement pathway of critical capacities in many levels with corresponding key process areas at each level (PMI, 2021). Each stage of CMM's support for organisations in prioritizing investment choices acts as a stepping-stone for the following level of improvement.

3.2 ORGANISATIONAL PROJECT MANAGEMENT (OPM3) CAPABILITY MATURITY THEORY RATIONALISATION

The capability maturity theory has been deemed more relevant in recognizing the relationships between the infrastructure management capabilities (independent variables) and the level of their maturity, and ultimate resilience that influence (dependent variable) service provision. The study

outlines a process towards resilient employee capabilities that are essential for assessing organisational resilience (van der Walt, 2020). OPM3 serves as a paradigm that connects infrastructure implementation and theory. Resilient employee capabilities are crucial in assessing organizational resilience, upon which the organisation is dependent (Hillmann and Guenther, 2021).

This study proposes that resilience in infrastructure management is dependent, and may be achievable - if Category B4 municipalities can adopt a framework for continuous improvement of employee IM capabilities. This involves corroborating with the ISO 9004 (2018) guidelines for performance improvement, suggesting that a sustained organisation improvement path can be achieved through continuous improvement of employees' competencies (Kerzner, 2019).

Organisational resilience requires a dedicated approach using models and tools for continuous improvement of capabilities to achieve expected results (Kerzner, 2019). Resilient employee capabilities are beneficial, when an organisation recognizes the necessity for resilience and its ability to undertake skills gap analysis on the existing employees and desired competency levels, and identify improvement areas (ISO 9004, 2018). In the collection of project management capability maturity models to support infrastructure management capability resilience, none is suitable for municipalities in the B4 category.

OPM3 implementation happens in three stages:

a) Understanding the model and putting it into reality;
b) Assessing current infrastructure management against project management techniques; and, most importantly,
c) Significant improvement by identifying the most urgent areas, and making the necessary changes.

Previous studies Pandya and Patel, (2019) in their research study used the OPM3 to assess the Project Management Maturity of Developers Organization in the Construction Industry. The study employed the project management maturity analysis methodology, consisting of multiple-choice questions that measure project management maturity, and cover all the 14 knowledge areas from which 10 are taken from the PMBOK rest 4 are from the literature review. The maturity model and methodology were then applied by benchmarking 5 different Developers organization. This assessment methodology provides solid and comparative studies in project management practice, project management tools and processes across industry and the companies. The OPM3

sought to guarantee that an organisation uses its resources appropriately and delivers out its projects successfully.

Whilst, in Douven (2021) the OPM3 model is based on the best practices and theoretical judgments confirmed by the experience of numerous organizations. In his research, Douven (2021) employed the OPM3 model to promote client retention while improving an organization's project performance, efficiency, and profitability. Thus, the maturity assessment of project management has been recognised as an important measure. The findings in Douven (2021) revealed that the higher levels of maturity in an organisation lead to improved project performance. Furthermore, having excellent project management skills would be extremely beneficial to any organisation that relies heavily on projects. Therefore, organisations with higher levels of maturity in their organisational project management (PM) exhibit better project management performance. The design parameters of standard capability maturity models provide a systematic maturation route and maturity levels. CMMs, can help the management of the organisations to define critical areas for improvement, prioritise such areas and put a strategy in place to improve the business process, while at the same time monitoring the implementation of such a strategy. As a result, maturity models can be used as a managerial as well as a benchmarking tool. Category B4 municipalities are affected by unique capability features, unconsidered by the standard CMM, so the study has included the resilience component in the design parameters of the capability maturity framework (MDB, 2018).

According to Andreas (2021), the unique progression characteristics are crucial in modelling the B4 category of municipalities' continuous improvement pathway in infrastructure management. Following a detailed introduction and discussion of the Organisational Project Management (OPM3) maturity model concept, it’s a successful usage as an assessment tool used in previous studies, its usage by the local government sector in terms of infrastructure management improvement pathways is explored. This thesis argues that there is a knowledge gap in the existing body of knowledge and, until now, there has been no practical study of municipalities in Category B4 that contribute significantly to a Capability Maturity Framework (CMF) for a continuous improvement pathway in infrastructure management capability.

CHAPTER 4: RESEARCH METHODOLOGY

This chapter describes the methodology used, justification of its use, and concludes by recounting the tools and processes used to collect data, as well as its intrinsic limitations. This chapter analyses the various paradigms, and their strengths and weaknesses, before concluding with a discussion that illustrates why a particular methodology is selected, and why it is deemed adequate for the study.

Urban and van Eeden-Moorefield (2018) designate research methodology as a systematic data gathering and analysis process to add to existing knowledge of the phenomenon of concern. According to Creswell (2018), in research, there are some basic guiding methodologies and philosophies that must be able to back up the credibility of the chosen research approach. There are various techniques based on various philosophies that represent the researchers' fundamental paradigms. Creswell (2018) describes the research design as the overall process to select data collection techniques along with data analysis procedures adopted in the research. According to Saunders, Lewis, and Thornhill (2019), research methodology should be defined within the context of research onion layers. This study uses the Saunders, Lewis, and Thornhill (2019) Research Onion Model to generate a proper research progression and design coherence.

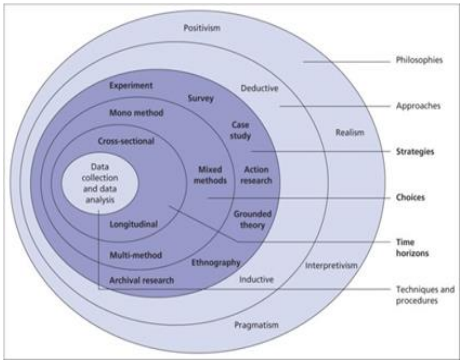


Figure 4.1: Research Onion

Source: Saunders, Lewis and Thornhill (2019)

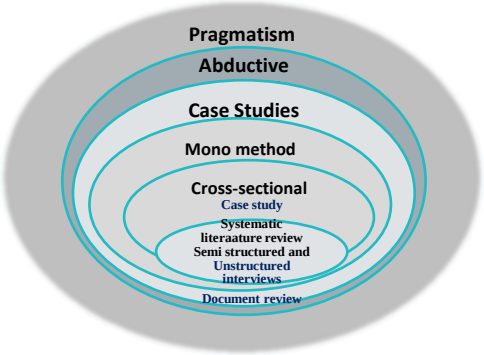


Figure 4.2: Adapted Research Onion

Source: Author

When constructing a methodology for this research, a six-layered Research Onion provided by Saunders, Lewis and Thornhill (2019) were followed. At the end of each layer the research explained the philosophy, approach and data collection methods chosen and the justification of the choice made. The research onion is a methodical overview of the many steps the researcher took in conducting this research, which made it easy to follow through each layer. The Research

Onion depicts how each layer leads to and forms the base for the next. Thus, researcher has considered several perspectives, selected a methodology, and a philosophical foundation in determining the most effective research strategies. As a result, the outline for chapter 4 reflects the six layers of this research from 1) philosophy; 2) approaches; 3) methodological choice; 4) strategies; 5) time horizons; and 6) techniques and procedures (refer to Figure 4.1 and 4.2).

4.1 RESEARCH PHILOSOPHY

Saunders et al, (2019) describes '*research philosophy'* as a set of thoughts, beliefs, and principles that determine how you approach your research. According to Mauthner (2020) research philosophies offer theories about the nature of the reality under investigation (ontology) and how knowledge of that reality is produced and justified (epistemology). When conducting a study, the researcher is supposed to express explicit philosophical opinions and responses to the research topic. There is also a need to consider how to bridge the gap between the declared philosophical perspective and methods of data gathering and analysis. It was critical to select a suitable research philosophical paradigm that paves the way for finding an appropriate answer to the research issue in a scientific and scholarly manner.

Among the variety of research philosophies available to researchers, there is positivism, interpretivism, realism, post-modernism, and pragmatism, as outlined by Saunders, Lewis and Thornhill (2019). In analysing the suitability of various philosophies to the phenomenon being studied in this research, the researcher initially identified positivism, interpretivism, and pragmatism as the philosophical theories most used by built environment researchers (Schwandt, 2017).

4.1.1 Positivist Research Philosophy

In the writings of Schwandt (2017), the positivist approach focuses on establishing a hypothesis, testing it, and generalizing the research findings to a larger population. The positivist paradigm has its roots in natural science, concerning the nature or operation of certain aspects of the universe (Saunders, Lewis and Thornhill, 2019). Given its origins in natural science, the positivist paradigm has a long history of rigour in the methods used to develop new hypotheses or test current ones about the nature or operation of the world system.

While the positivist viewpoint regarded numbers as the fundamental source of data, Creswell (2018) argues that the mathematical formulations used to interpret this data played an important part in human comprehension and knowledge expansion. Positivism remains a philosophical system embedded solely on scientific experiments and statistics (Bryman and Bell, 2021; Zaidan and Younus, 2022). The positivists scientific processes held by quantitative pillars, such as rigorous record-keeping and high precision, are still seen as critical components of a solid research methodology (Zaidan and Younus, 2022). Positivists think that the truth exists somewhere out there, waiting to be discovered, captured, and comprehended (Creswell, 2018).

Cooper and Schindler (2018) believe that researchers are hampered by a positivist inclination because of the replication crisis. The replication crisis remains a methodological conundrum that has emerged because of the failure of replication experiments, particularly in social psychology studies. The crisis has disrupted the scientific, ecological, sociological, and other positivist sciences, all of which are based on the premise of replicability.

Positivist thinkers believe that knowledge can be split into components and analysed separately; if all this is possible, a researcher can stand separately from the experimental subject. The basic philosophical premise of the positivists is that an observer or the instruments used by the observer are objective. As a result, positivists deem qualitative data less effective because it is inspired solely by subjective extended narratives, as opposed to statistical tables, based on quantitative analysis. Thus, positivism is mainly used by researchers conducting quantitative studies, connecting the real world to the mathematical representation of quantitative relationships.

4.1.2 Interpretivism

In social sciences, the interpretivist philosophy arose from a critique of positivism (Creswell, 2018). In social sciences, the interpretivist philosophy arose from a critique of positivism Interpretivism, is a quasi and ambiguous tradition wherein researchers interpret study aspects and incorporate human interest into a study varying on being a conservative, constructivist, critical, and deconstructionist method and neither method appears to be significant in the interpretive tradition (Bryman and Bell, 2021).

According to interpretative scholars, reality is socially created because it is made up of people's subjective perceptions of the outside world. Writings by Creswell and Poth, (2018); Cooper and Schindler (2018) assume that the only way to access reality (given or socially built) is through social constructions, such as language, consciousness, shared meanings, and tools. Interpretivism

gave substantial credence to subjectivism, a proven framework for qualitative research approaches (Bryman and Bell, 2021).

Academic research, according to interpretivist scholars, Cooper and Schindler (2018) can reveal many, equally valid realities. Central to the principle of interpretivism is to deal with the subjective interpretations that already exist in the social context; that is, to accept their presence, recreate, understand, and using them as basic building blocks in conceptualizing. The interpretivist's challenge is to access the social environment of the research respondents and appreciate it from their viewpoint (Saunders, Lewis and Thornhill, 2019).

Anti-foundationalists, interpretivists believe there is no unique standard approach to knowledge (Cooper and Schindler, 2018). Scholars aim to eliminate subjectivity as much as possible to produce scientifically sound research (Bryman and Bell, 2021). This study rejected the interpretivist subjective stance, which Daniel et al. (2020) argues was negligent of the capability to produce credible outcomes for policymakers.

4.1.3 Positivism and Interpretivism Compared

With reference to positivism and interpretivism, the philosophical foundations of each research paradigms are discussed. Interpretivism differs from positivism in that it focuses on adding richness to the collected data, whereas positivism aims to develop universal norms that can be generalized across all populations, without considering contextual circumstances (Alharahsheh, 2020). According to Saunders, Lewis and Thornhill (2019), the interpretivist viewpoint tries to get a better knowledge of the phenomenon in a complex environment, rather than generalizing it to other domains, which can lead to gaps in the verification of the results' validity. Statistical data is what defines positivism - on the other hand, the interpretivism method is defined by extensive subjective interpretations, and puts emphasis on qualitative analysis (Cooper and Schindler, 2018).

Saunders, Lewis and Thornhill (2019) concur that interpretivism is inherently subjectivist, focusing on complexity, depth, diverse explanations, and meaning making. Unlike the positivist-oriented research, which prefers quantitative methods to gather knowledge, this study does not contain a large sample of quantitative data, except for data from secondary documents and assessment scores measuring existing capability levels in Category B4 municipalities. The adoption of qualitative research as a legitimate form of enquiry was contingent on this type of study inquiry. Even though interpretivism, constructivism, critical theory, and other viewpoints

emphasize subjectivity in guiding qualitative researchers, the interpretivist approach was not suited for this study inquiry. Pragmatism, on the other hand, emerged as a method of inquiry for more pragmatic researchers.

4.1.4 Pragmatism

According to Saunders et al (2019) the beneficence of 'matter-of fact' actions is a signature of the pragmatist philosophy. The pragmatism philosophical movement arose from the rejection of traditional assumptions about the nature of reality, knowledge, and inquiry (Creswell and Poth, 2018). The idea that social science inquiry could only access reality by utilizing a single scientific technique was completely rejected by pragmatic scholars (Creswell and Poth 2018; Kaushik, 2019). Researchers who are pragmatists emphasize the research question over philosophical considerations (Creswell and Poth, 2018). Pragmatists are therefore not bound by any philosophical assumptions (Kaushik, 2019). Pragmatism's epistemological tenets centre on effective action, problem-solving, and practicality (Kaushik, 2019).

On the same wavelength, Saunders et al (2019) submit that 'turning to practice' is one of the main concepts in pragmatism. According to pragmatists, concepts are only important when they facilitate action (Saunders et al., 2019). The notion of reservations and the feeling that something is inappropriate or amiss serve as motivating factors for pragmatists. This brings up an important pragmatist component: the subject of inquiry, which serves as a roadmap for research methodology and, ultimately, a 'practical solution' (Kaushik, 2019; Saunders et al.,2019).

The pragmatism ontological perspective supports the concept that reality is rich, intricate and dynamic. Pragmatism has lately been employed in social research as the epistemology, driving mixed and multiple methods, since it rejects traditional philosophical dualism of objectivity and subjectivity. The focus of pragmatism is on the process of research rather than abstract arguments to accommodate sceptics (Saunders, Lewis and Thornhill, 2019). The pragmatist researcher's willingness to choose one version of reality over another is defined by how well that choice produces expected or desired results. Pragmatists posit that knowledge and reality are founded on socially constructed ideas and traditions, which is a basic precept of pragmatic philosophy (Kaushik, 2019).

Understanding the world according to pragmatists, is a creative human endeavour in which one's own ideas are shaped in accordance with how individuals are influenced practically, especially

in future studies (Kaushik, 2019). According to Saunders, Lewis and Thornhill (2019), researchers who follow either the quantitative or qualitative paradigms appreciate the usefulness of each paradigm for answering specific types of questions, as well as the extra depth that comes from mixing research methodologies. As a result, the researcher takes a pragmatic epistemology approach to the study.

4.1.5 Pragmatism in Infrastructure Management

Saunders et al. (2016) submit pragmatism is an appropriate philosophy for management research due to its problem-solving nature and integration of multi-methods approach. In this thesis, the broad areas of business and management are especially explored within the context of infrastructure management. Wasim et al. (2020) employed a pragmatic strategy in developing a framework that, in a more rigorous and reliable manner, allowed the assessment of construction companies with respect to bankruptcy prediction. Johari and Jha (2020) followed a pragmatist methodology to create a practical design framework for the fabrication and installation of modular building components. According to Johari and Jha (2020), pragmatism emphasises positive experiences as a way to guide future practice in manufacturing and assembling of prefabricated systems. Pragmatic methodology has been applied in construction project management with results. Problem solving and the application of multiple methods are prevalent themes in the above-mentioned research studies.

4.1.6 Justification of the Chosen Pragmatist Philosophy

Every philosophical position has advantages and disadvantages (Saunders et al., 2019). One of pragmatism's primary advantages is the latitude it gives the researcher. According to the pragmatist research paradigm, researchers ought to choose the methodological and/or philosophical strategy that best addresses the particular research question at hand. This freedom of choice allows researcher to seamlessly transition between quantitative and qualitative settings, customising their strategies to the specific research problem at hand. In a similar vein, pragmatism's emphasis on problem-solving is yet another benefit why the researcher chose this philosophy (Wasim et al., 2020). With this kind of thinking, the researcher in this study concentrated on providing workable solutions to a problem in line with the variety of methodologies the researcher can employ.

The challenge at hand, the '*resilience gap'* is the engineering staff competencies in Category B4 municipalities, persuaded the pragmatism paradigm choice. Saunders et al., (2019) posit that a pragmatist philosophical stance bore a domain of indeterminacy. Nevertheless, researchers adopting a pragmatist approach have more interest in practical outcomes waiting to be rationalized, which was the interest of this study. Pragmatism epistemology accommodated the use of varying data collection techniques, giving freedom of choice to either quantitative or qualitative methods or otherwise, a multi-choice method (Cooper and Schindler, 2018), the guiding determinant being the research question that one sought to answer (Creswell, 2018).

Unlike positivism and interpretivism, where the goal is to inevitably find truth or make connections, the pragmatist goal is merely to provide answers to questions. It was important for this study investigation to adopt a pragmatic philosophical viewpoint against the positivist 'law-like generalizations that have little to no bearing on causation. The appeal for diverse viewpoints by pragmatists was the primary strategy selected to answering the research question (Daniel et al., 2020). Convinced by Cooper and Schindler (2018) the researcher believe pragmatic approaches provide a valuable opportunity to make strategic analytic decisions, such as determining an optimal balance of insider and outsider perspectives, and to broaden existing knowledge on capability maturity framework. Pragmatism proponents (Kaushik, 2019; Alharahsheh, 2020) advocate for doing '*what appears to work'* to research, evaluate, investigate, describe, and interpret the phenomenon. Likewise, as described in Saunders, Lewis and Thornhill (2019), an underlying practice improvement of the study phenomena, warranted the researcher to lean on the pragmatist epistemological orientation.

4.1.7 Limitations of Pragmatism and Mitigation Strategy

Although the pragmatist philosophical attitude implies an indeterminate domain indeterminate domain, researchers who adopt a pragmatist approach are more interested in practical consequences that are waiting to be justified, which was the focus of this study. Diverse scientific philosophies inform different research approaches, which are characterized by specific aims, assumptions, and data sources. The next research layer discussed is the research approach.

4.2 RESEARCH APPROACH

Cooper and Schindler (2018) indicate that research studies may either assume a deductive, inductive, or abductive approach. Cooper and Schindler (2018) posit that pragmatism encourages the use of many methodological approaches, and that an inductive, deductive, and, when necessary, abductive reasoning serves as a basis for solid research. In various fields of management studies, inductive research frequently entailed qualitative research methodologies, such as case studies and ethnography, such as organisational behaviour, organisation theory, and strategy (Bryman and Bell, 2021).

The grounded theory is enhanced through the implementation of an inductive approach to qualitative research and is commonly associated with theory development, moving from collecting observed facts to theory (Daellenbach, 2018). Inductive research begins with unsolved questions concerning a particular phenomenon of interest, rather than a theory to be refuted or affirmed. In other words, inductive researchers do not require any underlying hypotheses because their focus remains on how the study question and findings go beyond what was already known (Creswell and Poth, 2018).

According to Rashid et al. (2019), all social science studies must begin with a theory, based on a review of the literature pertaining to the subject under enquiry, and this theory must then be validated through the study of a specific object, phenomenon, or social problem. The key point is that a theory must be constructed before it can be validated. In other words, rather than a deductive process, a theory or theoretical framework emerges through the inductive process. Inductive research does not require hypothesis testing, thus statistical techniques are rarely used (Creswell and Poth, 2018). Instead, inductive researchers must exhibit and synthesize their qualitative data into their research findings.

Contrary to the inductive approach, a deductive reasoning originates with just about any theoretical foundation and then derives several different hypotheses. Deductive researchers are expected to begin their studies with detailed introductions that justify their theoretical starting points and hypotheses that allows these to be proven from theory to context reform (Daellenbach, 2018). Despite its popularity, the deductive approach has recently been questioned in several domains (Gilgun, 2019). There are studies that incorporate theory into research, which Gilgun (2019) describes as neither purely deductive nor purely taking the extreme inductive position of grounded theory, but rather on the deductive-inductive-continuum. Researchers using an

abduction research approach, in exploring a phenomenon starts with data collection, classify thematic areas, and identify patterns before proposing new theories or adapting an existing theory, and finally testing the theory through supplementary data collection (Saunders, Lewis, and Thornhill, 2019). Gilgun (2019) refers to this type of reasoning as abductive, as it expands knowledge, produces creative ideas, and thus generates new theoretical inferences.

Based on existing rules or theoretical knowledge, Awuzie and McDermott (2017) view abduction as a process of generating a consequence such as the best explanation for an observed phenomenon. Qualitative researchers are frequently confronted with the challenge of choosing an ideal approach to situate their research. Awuzie and McDermott (2017) adduce the rationale why the selection of research approaches remains important. The task of setting a strong correlation between theory and research remains tricky for qualitative researchers. Saunders, Lewis, and Thornhill (2019), point out that at the start of a scientific investigation, theory may not appear to be important, however, arguing that its importance during the presentation of research findings and conclusion phases, respectively, requires the researcher to decide at the outset of the investigation.

According to Awuzie and McDermott (2017), the abductive approach allowed the researcher to move back and forth between theory and data in order to generate new or modify existing theory. The capability resilience first-hand acquired data was utilized to create the theory, which was informed by observations made on the elements during the assessments conducted using the existing maturity levels prescribed by the Organisational Project Management (OPM3) capability maturity framework (PMI, 2017). The existing PMBOK knowledge areas are deemed appropriate to observe the current capacity in Category B4 municipalities, as an initial position designed to produce a conceptual capability maturity framework.

Figure 4.3: Research Approach

Adopted from Saunders, Lewis and Thornhill (2019)

According to Saunders et al., (2019) a researcher using an abductive approach gathers data to explore a phenomenon, identify themes, expound and analyse patterns, to generate a new or modify an existing theory which you then verify through additional data collection. This is the process the researcher followed in this qualitative study. According to Saunders, Lewis, and

Thornhill (2019), pragmatists ponder roles played by theories, concepts, research findings, and hypotheses as instruments of action, as opposed to abstract form. The researcher followed an abductive process to assess maturity levels thereafter modify the existing model, starting with a set of observations about the elements of the existing OPM3 model and progressed from those observations to broader generalizations about those observations. The data was then used to recognize early patterns on several OPM3 levels to guide the investigation in the case study category B 4 municipalities, and identify common themes that were used to explain and develop the municipalities' infrastructure management capability improvement levels. In this study, an abductive reasoning was deemed the best approach for achieving the study's goals. The next layer of the research onion is the discussion of the methods used to gather information from the respondents.

4.3 RESEARCH DESIGNS

There are numerous methods based on various philosophies that represent the fundamental paradigms of the researchers. Creswell (2018) claims that the usage of diverse methodologies and strategies were determined by the research topic, the objectives of the research, and the research field. The primary purpose for choosing a research design, according to Yin (2018), was first and foremost the type of question given, would a '*what*' inquiry, for example be well addressed by an archival review, or even a case study? Perhaps, what research strategy was best suitable for developing causal answers for '*why'* questions (Yin, 2018)? Lastly, a focus on contemporary, as opposed to historic events, plays a major role in deciding which method to use. According to Saunders, Lewis, and Thornhill (2019), archival research, grounded theory, action research, surveys, and case studies are different research designs that could be used as outlined. The section then goes on to detail various qualitative research designs and gives an explanation of why a particular method was chosen for this study, and why it was determined to be appropriate.

4.3.1 Grounded Theory

In Charmaz (2020), grounded theorists, Glaser and Strauss, are widely acknowledged as pioneers of this theory, with Glaser being well-versed in descriptive statistics, while Strauss knew symbolic interactionism. When grounded theory was first introduced, these founders cautioned against studying about the research topic before beginning data collection or even later in the investigation. According to Glaser and Strauss, in Charmaz (2020), the premise was that

refraining from a review of literature would allow the theory to evolve from the information rather than being imposed from the available literature. Creswell and Poth (2018) remain highly laden with positivist/post-positivist epistemology that suggest that the researcher should be removed from the research process in order to discover or allow one objective theory to emerge. Gilgun (2019) claims that grounded theory was a systematic yet adaptable method.

Researchers were encouraged to use grounded theory when little was known about a phenomenon, and the purpose was to build or construct an explanatory theory that clarifies a process inherent to the substantive field of investigation (Gilgun, 2019). In the writings of Charmaz (2020), grounded theory tried to examine the real world primarily through the use of interviews as a data source and the construction of grounded concepts from data.

The concepts grounded in the data are used to build theory, the reason being that data analysis involves searching for concepts behind the actualities recorded in the data. In most research investigations, according to Creswell and Poth (2018), the literature review usually precedes data collection and analysis, since it allows the researcher to situate the inquiry within current knowledge. Glaser and Strauss, in Charmaz (2020), highly recommend a literature review from diverse fields in order to comprehend as many theoretical guidelines as possible. On the contrary, conducting literature review prior to data collection and analysis can be a constraining restricting exercise rather than a guiding leading practice (Charmaz, 2020).

Whereas, Chowdhury and Shil (2021) recognize that it must be the researcher's objective to develop a theory using the methodology, not the research methodology aim to discover a theory ignoring the researcher. Critics of grounded theorists argue that reviewing literature from various fields in order to understand theoretical guidelines is no different than reading directly related literature on the topic, as it could still result in significant contamination of the theory, which is what delaying the literature study is intended to prevent.

This research was not solely based on the epistemological assumption that conducting a literature review before collecting data hinders the development of a grounded theory. In this study, the literature review preceded data collection to allow the researcher to situate the inquiry in the wake of recent knowledge (Bryman and Bell, 2021). Adopting a pragmatic approach, the researcher had to begin with a literature review, in accordance to the research governance, as ethics committees anticipate at least a review of current literature as part of the study's rationale (Bryman and Bell, 2021). Charmza (2020) believes the researcher should disclose how the literature

review was used to build the theory in a transparent manner, as transparency remains the cornerstone of social science.

4.3.2 Archival Research

Cooper and Schindler (2018) characterize archival research as the methodical exploration and analysis of materials and sources to establish facts and reach new conclusions. Files, organizational registers, catalogues of names, polling data, and other relevant publications are examples of materials and archival documents. The review of archives existed consequently to advance the domain knowledge, the maturing of theories, and the creation of future research themes (Creswell, 2018). Cooper and Schindler (2018) believe that publication features could also be employed in the analysis to break down the total sample into intriguing strata to look for new perspectives and trends.

Creswell and Poth (2018) assume that studies based on literature reviews characterize mainly the sample they have included [for example, specifics of the sample in a survey and or case study and respondent selection in a case study, etc.]. According to Cooper and Schindler (2018), based on the publication year of the published papers, archival researchers may be able to determine when various themes emerged (or disappeared), suggesting the thematic evolution and trends of the issue's area of interest. Literature reviews are becoming increasingly popular as a stand-alone research method, and these method-specific principles were prevalent (Creswell and Poth, 2018). However, an archival review was not suitable to be deployed as a separate strategy in this study, as human experiences were required.

4.3.3 Action Research

Academics and practitioners use action research to blend theory and practice, and to transform and reflect on a current topic (Coghlan and Mani, 2021). In contrast to most research that gives descriptive theories, action research remains a fundamentally proactive theory. This type of research, according to Creswell and Poth (2018), entails an iterative process in which scholars and practitioners collaborate on a series of activities, including the identification of the research problem, action intervention, and reflective learning. It is a type of research that aims to improve the performance of both practitioners and organisations. Charmza (2020) suggests that action study focuses on bringing about organisational transformation, establishing self-help competencies in organisational employees, and adding to scientific knowledge all at the same time.

Since this type of study is taken by people who are researching their own environment, for example, in this case, technical employees in the Category B4 municipalities would be deliberating on how to remain resilient in their infrastructure management capabilities. Action researchers not only determine why an organisation functions, but also prescribes how they should function. The central notion of action research is to make research relevant by allowing scholars to actively test their hypotheses with real-life situations (Creswell, 2018). As a result, this strategy was deemed inappropriate for this type of study, as this study was explanatory.

4.3.4 Phenemological Study

Husserl (1931), cited in Creswell and Poth (2019), first imagined phenomenology as a qualitative research approach to comprehend the lived experiences of research participants and the meaning of those experiences. Phenomenological research intersects with other mostly qualitative designs. Pure phenomenological research tries to describe rather than explain, and it begins without any hypotheses or preconceptions. Phenomenology focuses on individuals' meaning making as the central element of the human experience. The significant results drawn from phenomenology are a knowledge of a phenomenon as seen through the eyes of individuals who have experienced it. Although the phenomenological technique provides the highest opportunity of gathering rich and accurate data according to Creswell (2018), it was not used for this study, because numerous case studies were being investigated. Phenomenologists tend to lean on one case study.

4.3.5 Ethnographic Study

The origins of ethnography can be traced back to anthropological studies that concentrated on the social and cultural elements of small communities in other nations. According to Bryman and Bell (2021), ethnographers' refrain from putting conceptual and theoretical frameworks on empirical data from the start of the study process. Ethnographers engage in participant observation and interact with the target population as much as possible in their ordinary everyday lives, while learning as much as they can about that culture and environment (Creswell and Poth, 2019). Thus, the classic anthropologists were aliens in their field settings. Since its origins in the study of indigenous/isolated peoples, this method has expanded to include any study whose research topic generally addresses the relationship between culture and behaviour and/or how cultural processes evolve through time. In order to answer these research questions, ethnographers frequently spend a significant amount of time living among the people they are researching. Data collection in these types of studies is through observation, as a result, this

strategy was deemed inappropriate for this type of study, as this study was not driven by observations.

4.3.6 Case Study Research

Since a case study can be both a design and a research approach, defining case study research, and the context in which it may be applied seems to be difficult. Yin (2017) defines case study research as real research that analyses a contemporary phenomenon inside its real-life context. The nature of the investigation determines whether a case study technique is appropriate. According to Creswell (2018), case study methods are best suited when the boundaries between phenomenon and context are not obvious, and in instances where numerous sources of evidence are utilised. Case studies are the chosen method when asking '*how'* questions, likewise when the researcher has low control over activities (Creswell and Poth, 2017).

One of the most useful benefits of the case study method is to explain real-world, causal relationships, with the researcher being able to comprehend the subjective richness of participants recounting real experiences in each setting (Creswell, 2018). Alpi (2019) emphasizes that in case study research, an investigator studies a real-life, a contemporary bounded system (a case) or multiple bounded systems (cases) over time, using detailed, in-depth data collection involving multiple sources of information. Case studies necessitate a variety of data gathering methods including archival documents, interviews, as is the case in this study, the findings of which should converge in determining notion cogency.

Creswell (2018) reiterates that numerous sources of evidence in case study research are key for data convergence and triangulation. Other data collection approaches in case study research, include participant observations and direct observation, which occurs when a researcher visits the locations. Yin (2017) maintains that a case study investigates a phenomenon by way of gathering information in one or multiple entities (people, groups or organisations). The researcher employed the case study as the primary technique of investigation in this study.

4.3.6.1 Case Study Procedures

The case study method has two approaches. Gehman et al. (2018) maintain that a single case or several cases might be used when undertaking case studies. However, diverse cases are sometimes considered as a totally different approach (Yin, 2017).

In this study inquiry, six cases of Category B 4 municipalities in the Eastern Cape and North West Provinces with similar engineering skills deficits were investigated. Due to the obvious depth of information inherent in its complexity, data from these various cases were compared to draw generalizable conclusions. Evidence was sought in various circumstances without direct comparisons of these multiple cases. Similar encounters were prevalent in each case, therefore there was a search for patterns of convergence and divergence that pervade all four case study municipalities.

4.3.7 Case Identification Processes

Case identification is influenced by the study's design and the characteristics of the actual case (Yin, 2018). Inferential risks of either technique were considered before making a sampling choice. Purposive sampling was used in selecting Category B4 municipalities with specific circumstances in connection with this study that could not be obtained through other means. The embeddedness of case study design in answering how Category B4 municipalities are experiencing the most infrastructure management challenges, makes it the preferred choice for this study (Yin, 2018). The researcher included cases in the sample because they were thought to be relevant.

The Eastern Cape and North West Provinces were selected as case study provinces representative of the precise attributes of the Category B4 municipalities under enquiry. Almost all Category B4 municipalities had a history of failing to maintain and operate long-term sustainable infrastructure services (Government Performance Index, 2019). Due to apartheid-era restrictions on economic development in black areas, rural Category B4 towns were unable to build sustainable revenue streams. Category B4 municipalities were unable to attract and retain highly skilled technical people to manage infrastructure and offer services due to their poor tax base (Brathwaite, 2018). The Category B4 municipalities are worse off, given the major skills constraints shown with engineering staffing ratios of 0.01 (MDB, 2018). The B4 category of municipalities perform the lowest performance on service delivery scores (Government Performance Index, 2019). Likewise, the province of the North West was among the most overburdened on municipal technical services. The 894 people served by one technical employee in this province exceeds the national average of 605.

4.3.7.3 Unit of Analysis

The units of analysis were the case study municipalities and the key informants and documents reviewed were the unit of observation. Likewise, expert groups from the built environment who gave feedback and informed the design process, based on the notion that they warrant inclusion, were the unit of observation. The case study research strategy was deemed appropriate for this study and justification has been provided I the next paragraph.

4.3.8 Justification of the Case study

Over time, case studies have evolved and gained a reputation as useful tools and a methodology for examining and grasping trends and difficult situations (Bryman and Bell, 2021; Creswell and Poth, 2018; Yin, 2017; Alpi, 2019). In the built environment sector, case studies were amongst the most utilized qualitative research methodologies. Nonetheless, case study design and implementation remain a complex and contested subject among academics (Schwandt, 2017). Managing infrastructure entails all project management processes that can be explored through case studies to identify unique and general challenges linked to infrastructure management. Researchers in the field of construction management have adopted case study strategies in providing solutions to construction related problems. Lack of engineering skills and infrastructure management capabilities has not been an easy situation for Category B4 municipalities, who still struggle with service provision.

Case study research tries to address precise methodological impediments. The nature of this thesis, which focused on developing a capacity maturity framework for resilient infrastructure management in Category B4 municipalities, qualifies it for use as a case study strategy.

Resilient infrastructure management was becoming a new trend that would stick around for the duration of a project-life cycle. In addition, resilience in infrastructure management is often occasioned by events that the researcher has little or no control over. Likewise, researchers who want to conduct a small-scale study or compare a modest number of organizations would consider using a case study as a research technique. Researchers using case study methods, can deal with unique situations wherein there are many more variables of interest than datasets (Yin, 2018). As a result, case studies have advanced in sophistication to become a valid method of inquiry for delving into a wide range of complicated situations, particularly when human behaviour and social interactions are key to comprehending the subjects of interest.

4.3.9 Benefits of Case Study Research

a) Case study research supports a variety of research methods, allowing the researcher to choose and adopt whichever strategies best address the research problem, which is consistent with the pragmatism philosophy used in this study.

b) Case studies can be used to address complicated social conditions or interventions incorporating several variables.

c) Case studies provide the opportunity to investigate a phenomenon in its context and are thus regarded as an important research technique, when studying the world around us.

d) Case studies lead to the development of theories that are applicable in the real world.

e) They allow the researcher to experience the world and contribute the researcher's opinion on the theoretical stance in the study, through own eyes.

f) Other qualitative approaches, such as grounded theory or phenomenology, offer less flexibility than case studies (Charmaz, 2020)

The case study is clearly a relevant and appropriate tool for understanding a complex matter, such as human behaviour. In comparison to other methods in the field of social science methodological approach, the case research represents study phenomena adequately. In management and business research, the case study as a mechanism for creating and evaluating theory, has recently witnessed a resurgence (Charmaz, 2020). It has been stated that a case study's perspective was to undertake a pragmatic inquiry into a current occurrence. The decision to use case study for this research was dependent on the degree of focus on contemporary as opposed to historical events, the type of research questions and the extent of control of behavioural events (Alpi, 2019). The research questions for this explanatory thesis included the '*how'* types which are consistent with case study research (Yin, 2018). Having determined the appropriateness of adopting the strategy, the first step in designing case study was constructing the theoretical framework for the study.

Municipalities were identified as case studies to assess the capability maturity status, using the OPM3 model and to identify the key improvement areas to be incorporated in the framework. Together with the identified expert group in the built environment, the researcher employed an abductive approach, firstly by using the inductive inferences from the known premises by drawing inspiration from the existing CMM, as outlined in Saunders, Lewis and Thornhill (2019).

Thereafter, data were collected in the field, themes were identified to modify the existing model and develop an infrastructure management resilience conceptual framework for the municipalities in the B4 category, as detailed in the research design section.

4.3.10 Criticism of Case Research Method

Criticism of research methods is unavoidable in the field of science (Charmaz, 2020). Varieties of criticism have been levelled at the case study technique, including concerns about generalizability of findings, management of the research quality and subjective bias (Bryman and Bell, 2021).

4.3.10.1 Case Study Findings Are Not Generalisable

In the field of science, the generalisability of case research findings is questioned, and there are restrictions when formal generalisation becomes the only viable approach to scientific investigation. Although the case study research investigates a small sample but it covers a wide range of different variables. This research method is well suited to generating a multitude of accurate and useful data that are not gathered out of context. This is one of the benefits of the rigorous case study, wherein internal validity is fairly high. It should be noted that the goal of case study, whether single case or multiple case studies, is not to acquire statistical generalisation or evaluate their representativeness, but rather their detail (Yin, 2018). The real purpose of case study is particularization, not generalization. Generally, the general knowledge is particularized in-depth into an individual case. That depth will be so deep that relations will emerge even in seemingly diverse circumstances. The detail was sought in this study through multi-case study. Furthermore, the researcher inclined this study on what Stake calls naturalistic generalization. According to Stake (2011) naturalistic generalisation occurs when readers gain insight by meditating on the facts and descriptions offered in case studies. As readers discover similarities in case study details and come across description that resonate with their own experiences, they decide whether their situations are comparable enough to merit generalization. Therefore, applying the naturalistic generalisation, the framework might be replicable in other contexts where similar situations that require continuous improvement pathway, whether it's in the field of software engineering, information system where capability maturity models originated.

4.3.10.2 Methodological Rigour Concerns

The rigour inherent in the case study approach is an issue that has been studied and has surfaced repeatedly in the management literature review. Concerns over methodological rigour and validity have beset the case study method. To eliminate bias in the results and subjectivity in the interpretation of the results, the researcher attempted not to limit data gathering to a single approach. Semi-structured interviews and document review were used in this context to obtain deeper, more in-depth, and detailed information. Qualitative methodologies were also used as part of the methodological procedure to provide rigour.

Three recommendations in Yin (2017) were revisited by the researcher to improve validity. Firstly, case study researchers should develop a clear research design showing that variable x causes outcome y and that y was not inadvertently created by a third variable. Secondly, researchers should compare observed patterns with either anticipated trends or patterns identified in previous studies and in different circumstances using pattern matching. Thirdly, the researcher uses theory triangulation to validate findings by combining multiple perspectives.

4.3.11 Measures for Overcoming Research Design Shortcomings

Regardless of methodological choice, appropriate consideration for study credibility metrics, such as construct validity, internal validity, and dependability will maintain a research's credibility (Creswell and Poth,2019). These four considerations were carried out in this study to overcome weaknesses in research design:

4.3.11.1 Construct Validity

According to Peels and Bouterm (2021), this pertains to making suitable operational measurements for the concepts being tested, in response to criticism that case study researchers sometimes fail to design adequate operational measures and rely on "*subjective*" judgements to collect data. The researcher aimed to build a coherent collection of information in case study municipalities to assist readers in reconstructing how the study progressed from the initial research questions to the results, to strengthen construct validity. Furthermore, data collection questions and measures were linked to research questions and assumptions.

4.3.11.2 Internal Validity

This is concerned with the ability of the overall research design to detect causal linkage relationships between the research variables when they exist. Various basic methodological

procedures are required to ensure high internal validity (Yin, 2018). In conducting the study, apart from employing multiple sources of data, all transcribed interview data was sent to the respondents to minimize the error and improve validity. It was because Yin (2018) posits that when results cannot really be explicit, inferences can be made. According to Yin (2018), it becomes difficult to establish inferences until all data sources have been properly cross-referenced to make a solid conclusion.

4.3.11.3 Reliability

Reliability deals with the robustness and consistency of the instruments administered at different times yet yielding consistent findings (Guthrie, 2021). This was achieved in this study by systematically documenting all the processes and procedures used in arriving at the research outcomes. The objective of documenting processes ensures that if another researcher were to conduct the same study all over again, the same findings and conclusions should be reached (Creswell and Poth, 2018).

4.4 DATA COLLECTION TECHNIQUES

The subsequent research onion layer was the data collection techniques and analysis methods selected to gain an understanding of reality and collect evidence about the world (Saunders, Lewis, and Thornhill, 2019). The overall aim of the research implies the choice of methods that may be preferred for reaching specific research objectives, namely, quantitative, qualitative, mixed or multi-methods (Saunders, Lewis, and Thornhill, 2019).

4.4.1 Choice of Quantitative or Qualitative Research Methods

In their writings, Bryman and Bell (2021) maintain that epistemologies are not linked to a particular research methodology. Nonetheless, the attributes and perspectives of all these are widely accepted epistemological paradigms. Owing to these research features, research methodologies have been historically segmented, with quantitative methods associated with positivism and qualitative methods with non-positivist epistemologies (Bryman and Bell, 2021). Various disciplines conduct qualitative research from different approaches when answering the research question. According to Creswell (2018), positivists take a restricted view of knowledge generation and attract quantitative oriented researchers who tend to focus only on what can be measured and observed.

4.4.1.1 Quantitative Research Methods

Quantitative research studies have a strong emphasis on causality and the separation of observer and knowledge (Creswell and Poth, 2018). According to Cooper and Schindler (2018), objectivity, replicability, and correlation are the cornerstones in most quantitative research studies. In their writings, Creswell and Poth (2018) associate quantitative research with variable-centred approaches including statistical inferences, multiple regression, exploratory factor, and correlational models. In the case of infrastructure management, for example, how many infrastructure divisions in Category B4 municipalities benefitted from the external support engineers, and how many were able to continue undertaking the infrastructure project management routines on their own without the help of the previously deployed support engineers? According to Cooper and Schindler (2018), correlational models are useful for determining how observed, or concealed variables, connect to one other and producing outcomes based on an averaged set of parameters. Similarly, Zaidan and Younus (2022) posit that the systematic and empirical analysis of the phenomena using numerical data processing remains a significant divide in quantitative research. The detractors of quantitative researchers believe that while data quantification can be beneficial in uncovering basic social processes, it has a tendency of hiding a wealth of details. Quantitative study lacks the resources to illustrate how the phenomenon gets presented on a local level (Chowdhury and Shil, 2021).

4.4.1.2 Qualitative Research Methods

Thelwall and Nelville (2021) define qualitative research as an iterative approach, in which scientists gain a clearer understanding of the phenomena under investigation by establishing new meaningful distinctions. Typical of qualitative research approaches are the personal contact between the researcher and the group under consideration over a long period of time (Bryman and Bell, 2021). In qualitative investigations, detailed descriptions of people's experiences lead to a richer and more comprehensive knowledge of phenomena (Cooper and Schindler, 2018), that would otherwise be overlooked or concealed in large-scale studies.

In qualitative studies, building a connection with study participants may lead to a greater understanding of the case under inquiry, thereby enhancing and enriching the data. Creswell (2018) goes as far as claiming that qualitative techniques are inductive, geared toward exploration and inquiry, and have a high degree of validity, whereas generalizability is accorded minimal

emphasis. The depth of information in qualitative investigations frequently prevents the wide range of participants found in quantitative research.

While this in-depth concentration is a strength, rather than a weakness of qualitative research, it does limit the kind of inquiries that qualitative research can and cannot resolve. More recently, some academics (Thelwall and Nelville, 2021) argue that qualitative methodologies such as in-depth interviews are challenged by big data capabilities. Thelwall and Nelville (2021) go on to say, if algorithmic methods can equally generate genuine insight as big data methods, qualitative research may become less important. Since the intention was to reveal relevance from the research subjects' perspective, and not statistical data obtained from a large number of respondents in the Category B4, a qualitative technique was deemed appropriate for achieving the intended results.

4.4.1.3 Mixed or Multi-Methods

Bryman and Bell (2021) maintain that in business research, multiple research methods are crucial in tackling the research objective from all possible methodological sides whilst overcoming the shortcomings associated with using mono-methods. Mixed or multi-methods designs are the foundation for pragmatism (Creswell, 2018). According to Saunders, Lewis, and Thornhill (2019), multi-methods research involves within-paradigm mixing, using multiple qualitative or multiple quantitative techniques to collect data and procedures to analyse collected data without mixing the two data collection approaches, as shown in the Multi-Methods Venn Diagram 3.5 below.

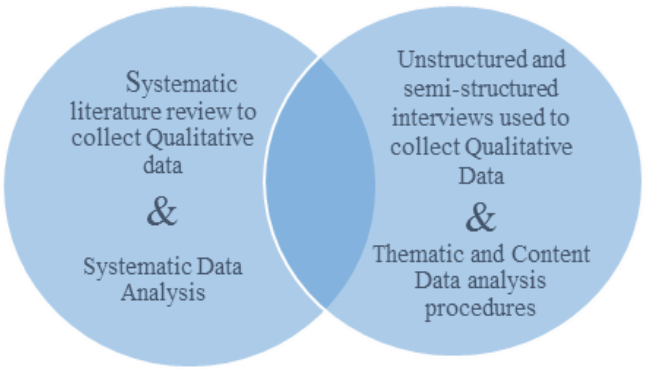


Figure 4.4: Multi-Methods Venn Diagram

Source: Author

4.4.2 Distinction between Quantitative and Qualitative Research

Presenting qualitative and quantitative research methods as emanating from two distinct worlds is common practice. On the one hand, qualitative research is sometimes treated sceptically and is given little value in quantitative circles, due to its small sample size. Small samples might not be regarded as typical of the general population, also are not viewed as objective, and the researcher's personal bias is deemed to be evident in the findings. On the other hand, in qualitative circles, quantitative research can be disregarded as understating an individual experience in the generalization processes, failing to recognise researcher bias and assumptions in research design, and necessitating guesswork to interpret the human meaning of data sets (Cooper and Schindler, 2018).

4.4.2.1 Quantitative Data

Quantitative research emphasizes quantification in data collection using a deductive approach, in which theories are tested (Van der Walt, 2020). The researcher may have no direct contact with the research subjects, when conducting quantitative research. The quantitative positivism method was therefore unsuitable for this study, primarily because the entire study to develop capability maturity framework for resilient infrastructure management capabilities in Category B4 municipalities required contact with people on the ground. Frequently, the researcher hires interviewers or emails the surveys.

On the contrary, Bryman and Bell (2021) believe this lack of involvement ensures that the researcher's objectivity is preserved. Deductive research approaches are often used by quantitative researchers who use theory or hypotheses to test them against facts. They focus on numerical statistical algorithms (Creswell, 2018). Except for secondary documents and evaluation scores assessing existing competence levels in Category B4 municipalities, this study did not contain a substantial sample of quantitative data. Unlike positivist-based studies that prioritizes quantitative approaches to obtain knowledge, the researcher was therefore not persuaded to use the qualitative approach.

4.4.2.2 Qualitative Data

By contrast, qualitative research uses an inductive technique to build theories. In getting knowledge, the researcher collected qualitative data using multi-data collection procedures to maintain the logical flow throughout the research structure. According to Cooper and Schindler

(2018), the emphasis on obtaining a depth of understanding that captures the viewpoints, experiences, or settings of specific individuals or groups is the overarching theme that runs across all qualitative approaches (typically with a small sample of participants or groups, as was the case in this research). Qualitative studies incorporate research strategies, such as ethnography, narratives, and case studies (Bryman and Bell, 2021).

In addressing the various study objectives, the data collection procedures are followed to deal with each of the study objectives. Also leaning on the goal of grounded theory to develop concepts based on evidence from the social environment (Cooper and Schindler, 2018), this research was grounded in people's daily experiences and behaviours. Awuzie and Dermott (2017) believe that the abductive approach appears to be gaining traction among qualitative researchers in the built environment discipline.

The abductive nature of the study entailed several sequences of data collection, coding, and analysis, as well as reflection. Firstly, the researcher carried out a literature review to compare the usage of PMBOK standard project management approaches for managing infrastructure by previously deployed support engineers to current technical personnel in Category B4 municipalities to address Objective 1, *"To critique the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel."* With the qualitative data collected the researcher delineated the required practices that should form part of the engineering skills improvement pathway. The stark contrast of quantitative and qualitative research is briefly outlined in Table 4.1.

Table 4.1: Differences between Qualitative and Quantitative Research

Qualitative Research	**Quantitative Research**
Storyline	Statistics
Participants' viewpoint	Researcher's viewpoint
Developing theory	Testing theory
Background appreciation	Generalisation
Rich, in-depth data	Solid, dependable data
Natural Setting	Setting Simulated

Adapted from Bryman and Bell (2021)

4.4.3 Choice of Qualitative Research for the Study

The distinction between qualitative and quantitative methodologies emphasized in most literature remains artificial. Both methodologies are relevant to perform research, but the approach is determined either by topic and study question. Thelwall and Nelville (2021) claim that expressing the usefulness and prevalence of a common methodology in a subject is beneficial. This is in recognition of the research approach choice, and its major contributions to a particular sector (Thelwall and Nelville, 2021).

Since it allows participants to tell the story of their experiences in their own terms and does not impose preset options, as does the quantitative research method, this approach was chosen (Cres well, 2018). The ability to explore novel themes that arose during the interviews was made possible by the flexibility of qualitative research. In addition, qualitative research is consistent with the selected theoretical frameworks, specifically construction management.

In this current study, qualitative research, rather than quantitative research, was considered. A qualitative research technique is usually employed by researchers who want to find significance from the perspective of the research participants and the items found in their environment (Creswell et al., 2018). Qualitative research is a well-regarded kind of inquiry (Bryman and Bell, 2021; Cooper and Schindler, 2018) and the intricacy that surrounds it (Creswell et al. 2018) demands rigorous and precise methods to provide relevant results.

Qualitative approaches (as opposed to quantitative methods) aim to get a deeper understanding of a phenomenon by relying on the rich meaning offered by words, signs, traditions, structures, identity constructs, and power dynamics. Only a qualitative approach to researching human behaviour would enable a deeper investigation into critical improvement areas that should be included in the resilient infrastructure management capabilities maturity framework. Given its flexibility, openness, and response to context, qualitative research was chosen as part of the data collection process (Bryman and Bell, 2021). The primary aim of the qualitative research is to get first-hand knowledge from participants and sources. The interviews were independently performed by the researcher. The underlying substantive theoretical framework has influenced the researcher's qualitative methodological choice. Although there are many critiques of the reliability of qualitative research, this method is effective in ensuring an equitable sample distribution and eliminating bias caused by the study population (Bryman and Bell, 2021) as

researchers doing qualitative investigations can collect data from a larger, randomly sampled population.

The use of thematic analysis, which is beneficial for summarizing critical components of big data sets, was an advantage of using qualitative research. Qualitative enquiry was used in this study instead of solely quantitative approaches, as its holistic approach was more suitable in examining the daily life phenomenon of infrastructure management capabilities of Category B4 municipalities. Qualitative research has been used in the study because of its strength. The study also used qualitative data from the semi-structured interview questions for inspiration and to provide direction, and elicit more information from a wide range of respondents, whilst the unstructured interviews and the semi-structured interviews were utilized for collecting data to deal with the latter Objectives 2-5. Plausible qualitative results obtained as answers to open-ended interview questions were collected using a rigorous qualitative methodology (explicit, transparent, and replicable) and research procedure. The ability and advantage to back up qualitative conclusions from literature review with qualitative interview data, was one of the benefits of using a variety of methodologies in developing the capacity framework for infrastructure management resilience (Creswell, 2018).

4.5 DATA COLLECTION PROTOCOL

Data collection protocols are the inner layer in the research onion, indicating techniques and methods employed to bring the research to life. Critical for a researcher is the ability to defend their methodological choice to firmly root their research within that discipline. The case study research technique was chosen by the researcher, because of its effectiveness in analysing an existing occurrence in its natural setting (Saunders, Lewis, and Thornhill, 2019). Interviews were a crucial component of this study, as it allowed interviewees to share their personal stories. The researcher did not expect that interviewee accounts would be objective factual statements, but rather genuine reflections of lived experiences.

When gathering data, the researcher was conscious of the risks of asking poorly worded interview questions (Creswell, 2018), as such imprecise guidelines could lead to confused measurement. The researcher created and used a qualitative interview guide as an instrument to collect evidence. The interview guide for this instrument included open-ended questions on the goals of the study,

as well as semi-structured questions about primary categories derived from current OPM3 theory. The researcher avoided asking leading questions to reduce errors and bias (Creswell, 2018).

Researchers typically choose face-to-face interactions because they allow for the appreciation of body language and other non-verbal cues, which is not possible when utilizing telephone interviews. Face-to-face interviews, however, were not used in this study because of the COVID outbreak making it impractical to travel across great distances to sampled locations. All of the interviews that were performed outside of the Gauteng Province used Zoom or Microsoft Teams. The interviews were dependent on participants having reliable internet connectivity. These interviews were undertaken as part of the data collection process in answering -

- ***Question 1*** "How does the usage of project management approaches for managing infrastructure by current technical employees compare to the project management approaches employed by previously deployed support engineers*?"* Following that, unstructured interviews were conducted to acquire insight on -

- ***Question 2 "***What infrastructure management skills were used by previously deployed support engineers to maintain reliable service delivery in Category B4 municipalities? and

- ***Question 3*** What are the various maturity stages in infrastructure management of Category B4 municipalities assessed using the capability maturity model (OPM3)?

Every informant agreed to audio recording of the interviews and follow-up discussions. Interviews were transcribed and compared to the audio recordings, wrote an interpretive summary of the participants' responses, and met with the participants again for member verification. After the member verification session and the confirmation of the participants' responses using the supporting organisation records, it was determined that data saturation had been reached. All of the participants agreed that the interpretation given was correct.

The use of various data collection techniques was accommodated by a pragmatic epistemology, which allowed users to choose between quantitative and qualitative approaches or a multi-choice method.

4.6 DATA ANALYSIS

Qualitative research seeks to embrace and understand the contextual influences on the research issues (Gehman et al., 2018). Cooper and Schindler (2018) characterize thematic analysis as an

explanatory means to reduce data in a flexible format that could be merged with other data analysis methods. The next section introduces thematic analysis.

4.6.1 Thematic Analysis

Thematic analysis is based on the premise that all information conveys meaning, which may be derived by identifying a central idea or a cluster of ideas that provides a comprehensive meaning whereas, Gehman et al. (2018) views thematic analysis as a popular but frequently misunderstood qualitative data analysis tool. Some qualitative studies use NVIVO for data analysis as this software allows for the investigation and exploration of themes and clusters as they emerged from the data. The respondents' files are imported and classified as cases, and memos and annotations are developed around those cases. The individual questions were classified as codes, and memos and annotations are developed around each of those codes on relationships between different questions and the cross-referencing of such questions. In this study, Creswell's five-stage data analysis procedure was useful in allowing distinct gathering, analysis, and interpretation of qualitative data sets (Creswell, 2018). The process entailed:

4.6.1.1 Data Logging of the Raw Data

Given the nature of the study, the researcher's initial task was to put together on a data file of all the completed interview transcripts. After the initial interview, the researcher had to become familiar with the raw data before generating specific codes. The obvious content became limited to the transcribed interview text from the interview guide, but hidden content included both the researchers' interpretations of available text, and participants' recesses, silences, moans, laughter, posture, etc. (Kampira, 2021).

4.6.1.2 Establish Efficacy and Depth of the Collected Data

Kampira (2021) suggests that every data analysis technique begins with becoming acquainted with a given dataset. It is worth noting, however, that there may be a need to become acquainted with a dataset as well as its context. For example, while doing thematic analysis with a deductive and/or realistic goal in mind, it is critical for the researcher to be completely familiar with the concepts, theories, models, and practice from which any data deductions are to be formed. As a result, the identification and extraction of themes in deductive research contexts will be directed by pre-existing and pre-identified viewpoints (Creswell, 2019).

However, with thematic analysis, Creswell (2019) maintains that data interpretation and theme development are guided by the dataset in question, whilst concepts and theories are generated using the data analysis as a starting point. In this study the researcher started interacting with the data to find clear patterns of meaning that were emerging from the data. The audio-taped interviews were transcribed prior to analysis. In this study data analysis on the lived experiences of the research participants added relevance to the first impressions and final collations of the researcher. Immersion in the data was important in the process of analysing the interview data (Creswell, 2019).

4.6.1.3 Organise Materials into Categories

The titles of the codes were established once the initial observations were considered. According to Creswell (2019), the researcher works to ensure that the process of theme abstraction remains rooted in the language of participants and requires employing the words and expressions that participants use. The researcher then recorded phrases that were deemed appropriate for adequately capturing the data gathered from multiple data segments. Finding patterns, words, or ideas that are similar emerge was the first step in the thematic analysis process.

4.6.1.4 Align Coding Process with Identified Categories

As suggested by Creswell (2019), codes were then moved around and grouped into clusters to identify logic in findings from identified patterns enabling data interpretation.

4.6.1.5 Pattern-Matching

According to Creswell (2019), the pattern matching logic compares an observed pattern to an anticipated configuration. Creswell (2019) argues that when the patterns coincide, internal validity improves. Kampira (2021) views thematic analysis as a valuable approach for analysing qualitative data in both academic and professional settings. Considering its compatibility with other qualitative data analysis procedures, it is a vital research procedure to fully understand. Pattern matching was used as the primary analytical tool in this study. Content analysis is another qualitative methodology used to examine textual data. In contrast to methodologies that focus on the data informational substance, qualitative content analysis, according to Kampala (2021), incorporates theoretical perspectives.

4.6.2 Content Analysis

According to Kampala (2021), content analysis is a broad umbrella term that involves qualitative data analysis procedures that aim to generate meaning from data through categorisation, classifying, and critique processes. As content analysis allows for data quantification, it can be applied to quantitative data analysis. Creswell (2018) describes content analysis as a research approach for analysing qualitative data for written texts. Creswell and Poth (2019) regard content analysis to be a systematic coding method that is used by researchers to describe and interpret textual data. Qualitative researchers often decide whether the apparent and/or underlying contents should be considered for analysis, based on the study objectives (Denzin and Lincoln, 2018). In this study, content analysis was utilized in analysing secondary data from documents, which included impact assessment reports of previous engineering support programmes, the National Treasury quarterly reviews on the status of local government in South Africa and the Municipal Demarcation Board municipal assessment reports.

The following steps were employed as part of the iterative data analysis process, through reading documents repeatedly to identify relevant data, building a coding frame comprised of main categories and sub-categories. This is the same content analysis procedure applied by Sprogis et al. (2021) in their study to understand the pre-medical emergency team level of a mature quick response organization.

The researcher used data segmentation following coding procedure to facilitate the identification of categories and patterns, which evolved into a process of analysing and arranging data to better understand meanings in the text (Creswell, 2018). Subsequent piloting and refining of the coding frame, the researcher concluded the main analysis, and interpretation of the results. Using a data-driven (inductive) approach, the coding frame was then evaluated against the data and spread to make sure the data was adequately reflected within the coding frame. Coding qualitative data was found to be equivalent to capability maturity modelling in that both involved working with large amounts of data and interpreting patterns and processes.

A spreadsheet was used to extract, encrypt, and code according to predefined categories informed by literature on capability maturity models and engineering skills in local government. The rigour of the analysis was addressed through double coding at multiple points in time, peer deliberations with research participants, and explicit proposed reporting techniques. Since the primary analysis was performed by a single researcher, the coding process was repeated 10-12 days after the

coding process was completed to ensure the reliability of the findings. Alpi (2019), in his writings, posits that research findings once analysed, should be methodically structured so that the relationship between the raw data and the classification matrix is readily visible and understandable. The parameters of the research enquiry could not be separated from analysis. The scope covered in this study is outlined in the following section.

4.7 RESEARCH SCOPE

The research scope, as defined by Denzin and Lincoln (2018), are the parameters within which the investigation is carried out, as well as what was covered in terms of problem conceptualization. The scope of the inquiry was confined to the four Category B4 municipalities in the population of interest in the provinces of the North West and the Eastern Cape.

According to Andreas (2021), engineering skills varied in many rural communities depending on local characteristics, but failure to procure and manage sustainable infrastructure services was a common trait in virtually all Category B4 municipalities. These traits contradicted the NDP 2030 vision of having public institutions capable of providing quality services to communities (IDMS, 2021). The B4 category of municipalities perform the lowest performance on service delivery scores in the Government Performance Index (2019). These Category B4s are failing to draw-in and maintain critical skills in the built environment (Lawless, 2015). As a result, many of these rural municipalities are facing problems in terms of delivering new infrastructure and maintaining current assets. The research design entailed an explanatory case study inquiry and case study evidence collected from four sites that met the sampling criteria in the North West and Eastern Cape provinces from among the twenty (20) Category B4 towns. Category B4 municipalities in these provinces record the lowest scores on service delivery indicators and have the most vulnerable technical services department respectively (MDB, 2018; LGSETA, 2018; National Treasury, 2018).

4.8 STUDY POPULATION

The study population of interest is the set of individuals that the researcher is interested in investigating (Creswell, 2019). When conceiving the population of interest, the researcher considered the eligibility criterion and the characteristics of '*the ideal'* research participants, study setting that informs recruitment of the target population of interest. Given that the research is time bound and the researcher would not have been able to analyse the entire population, due

to the timeframe and available resources, sampling techniques were used to reduce the number of cases. As such, a sample was chosen. The sampling process included the following stages:

4.8.1 Target Population

The population refers to the entire set of cases from which the researcher sample was drawn. South Africa has fifty-nine (59) municipalities that make a total population of Category B4 municipalities (MDB, 2018). The first step in the sampling process was to accurately delineate the target population. The Eastern Cape and North West Provinces have been chosen as case study provinces, because they are representative of the specific characteristics of the Category B4 municipalities under consideration. The target population for this study was then 26 Category B4's in the North West (11) and Eastern Cape (15**).**

4.8.2 Sampling

Since they may not have the resources or time to investigate the entire population, researchers have used sampling techniques to reduce the number of cases (Fowler and Kettler, 2022). Denzin and Lincoln (2018) describe sampling as a process to select a representative distribution of a smaller number of items of the population under consideration. The study population serves as the source of the sampling units. Depending on the sampling technique used, the researcher uses sampling to infer information from the population or to generalize about existing theory (Fowler and Kettler, 2022). Population sampling becomes useful in making extrapolations to the population (Guthrie, 2021). Although it saves time and money on the one hand, the level of objectivity in the results could be compromised.

The researcher may do the extrapolation, using either probability sampling or non-probability sampling techniques (Denzin and Lincoln, 2018). When using probability sampling techniques, every population element has a positive probability of inclusion in the sample (Guthrie, 2021). Random population sampling methods include simple random sampling, systematic sampling, stratified sampling clusters, and multi-stage sampling. As compared to random or systematic sampling, stratified sampling supports more accurate estimates when generally homogeneous and distinguishable strata (categories) are defined. Stratification improves the effectiveness of content sampling techniques by trying to reduce disparities within each stratum when there is a large difference between the strata values. Denzin and Lincoln (2018) posit that one method for conducting random sampling would be for the researcher to first create a sampling frame and then use a randomly generated computer simulation to select a sample from the sampling frame.

According to Guthrie (2021), the probability sampling provides the most valid or credible results because they reflect the characteristics of the population from which they are derived. Guthrie (2021) goes on to claim that probability or random sampling remains the least biased, for a given level of sampling error, yet is the most time and effort intensive sampling technique. The non-probability sampling approach uses non-randomized ways to draw the sample, in contrast to the probability sampling method. Purposive sampling, snowballing, convenience, and quota sampling are all non-probability sampling techniques. Most non-probability sampling techniques involve judgement (Guthrie, 2021). Participants are chosen because they are accessible, rather than at random. In Denzin and Lincoln's (2018) writings, non-probability sampling approaches are commonly used to gain an early understanding of under-researched groups, rather than theory testing on a large population.

Case study research design and qualitative research are frequently associated with non-probability sampling (Guthrie, 2021). Rather than just making statistical inferences about the entire population, qualitative case studies typically focus on small samples that are intended to investigate a real-life phenomenon (Guthrie, 2021). When sampling with a purpose, the researcher selects the participants using his or her own judgment yet keeping in mind the research purpose. In choosing cases, the researcher selects them using expert knowledge or with a particular goal in mind. Purposive sampling makes it difficult for the researcher to determine whether the instances chosen accurately reflect the population or not. Most sampling techniques might be regarded as purposeful in nature because sample issues are typically addressed with a specific plan in mind.

Purposive sampling makes it difficult for the researcher to determine whether the instances chosen accurately reflect the population or not. Creswell and Poth (2019) believe most sampling techniques might be regarded as purposeful in nature because sample issues are typically addressed with a specific plan in mind. Non-probability-based sampling is both time and cost-efficient compared to random sampling. Creswell (2018) states that case studies have a unique strength that accommodate multiple epistemological orientations, whilst linking specific methodological challenges, processes, and outcomes. A case study approach permits the researcher to select any data collection method that best fits their needs (Guthrie, 2021) if it is ethical and appropriate. Creswell (2018) posits that a sample of participants or cases does not have to be representative or random, but there should be a valid justification for including some

cases or individuals over others. The case study technique was utilized in this study, to identify research subjects with pre-set features (Guthrie, 2021).

4.8.3 Study Sampling Process

In answering the research questions, it is unlikely that the researcher will be able to collect data from all cases (Thelwall and Nelville, 2021).

The research project might include a large population that cannot be investigated all at once. The percentage of the population studied is referred to as a sample (Gehman et al., 2018). In this study, a sample was drawn from a big population of Category B4 municipalities using a specific process.

4.8.3.1 Select Sampling Frame

Gehman et al. (2018) define a sampling frame as a list of the actual cases from which the sample will be drawn. According to Denzin and Lincoln (2018), once the target population is established, the researcher chooses a sample from the sampling frame. The sampling frame must be representative of the population to make inferences about a population or make a generalization grounded on existing theory (Gehman et al., 2018). Denzin and Lincoln (2018) then challenge researchers to always seek to close the gap between a truly representative sample of the target population, dubbed "*the ideal sample,"* and the observed sample. Concerns about sample representativeness also arise when considering how a sample would validate or invalidate an inference. As a result, the researcher was alert to bridge the gap between the target population of interest and the observed sample to generalize the findings across the unobservable population from which no data were sampled.

4.8.3.2 Choose Sampling Technique

The researcher has two choices, probability, and non-probability sampling. Choosing a sampling technique is heavily influenced by the study objectives and method, which Denzin and Lincoln (2018) relate to as a sample fit for purpose. The selection of qualitative or quantitative research methods does have an influence on sampling techniques because they are generally associated with the method (Andrade, 2021). The most popular probability sample is simple random sampling since each member of the population has an equal chance of being chosen. Although it might not be the best way for selecting the sample, the results acquired using this method have higher external validity or generalizability than those from methods using other small samples

(Denzin and Lincoln, 2018). The probability sampling technique allows for inferences and extrapolations about a study's target population. It is important to note that the use of probability (random) sampling techniques is most notable with quantitative studies, where statistical methods such as appropriate sample size, random errors, and results precision can be determined (Andrade, 2021). According to Denzin and Lincoln (2018), probability sampling reduces the risk of bias in research results.

Unlike the probability sampling method, the non-probability sampling strategy draws the sample in a non-randomized manner. Convenience sampling, purposive sampling, quota sampling and snowball sampling are all examples of non-probability sampling. Respondents who are easily accessible or available to the researcher are considered for convenience sampling (Andrade, 2021). Most non-probability sampling methods use judgement. When using non-random sampling, participants are picked because they are conveniently reachable instead of picking people at random. With this type of non-probability sampling technique, everyone who interacts with the researcher is eligible to participate in the sample. Whereas a non-probability-based study cannot make empirical associations that are generalizable beyond the participant group. Purposive sampling was used to best match the sample to the research's aims and objectives, improving the study's rigour and the reliability of the data and results. Purposive sampling was used to select Category B4 participants, who had specific circumstances related to this study that could not be obtained through other means.

4.8.3.3 Determine Sample Size

The sample sizes reflect the range of respondents obtained rather than the number of questionnaires distributed. Large probability samples are common in quantitative research, and while it is true that the larger the sample size, the smaller the error, Creswell, and Poth (2019) maintain that in qualitative case studies, researchers are seeking for thick descriptions rather than sample size. Municipalities in the case study provinces with similar characteristics were grouped together during sampling, to guarantee that at least one of those groupings was represented in the study sample as indicated in Tables 4.2 and 4.3.

Table 4.2: Attributes of Category B4 Municipalities - Northwest Municipalities

Attributes	**Moretele**	**Madibeng**	**Rustenburg**	**Ramotshera**	**Tswaing**	**Ratlou**	**Naledi**	**Mamusa**	**Maquasi Hills**	**City of Matlosana**

Categorized dysfunctional	○				○					
Poor debt collection on own revenue	○	○		○						
Section 139 intervention		○		○					○	
No Registered engineer			○							○
Persistent CAPEX underspent over the past 3 financial years	○							○		
Scored (3) on grant reliance on a scale of 1-3	○									
Less than 50% household receiving refuse removal service	○	○		○	○	○		○		

Source: MDB (2019)

Table 4.3: Attributes of Category B4 Municipalities - Eastern Cape Municipalities

Attributes	**Ntabankulu**	**Mbizana**	**uMzimvubu**	**Ngqshwa**	**Mnquma**	**Mbashe**	**eMalahleni**	**Engcobo**	**Intsika Yethu**	**Senqu**	**Elundini**	**Mhlontlo**	**Ngquza Hill**	**Port St Johns**	**Nyandeni**
Categorized distressed or dysfunctional		○			○							○			○
Poor debt collection on own revenue	○				○					○		○			○
Section 139 intervention												○			
Registered engineer	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Persistent CAPEX underspent over the last 3-FY	○				○	○				○		○			○
Scored (3) on grant reliance on a scale of 1-3	○				○				○			○			○
Less than 50% household receiving refuse collection	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Source: MDB (2019

Summarized in the tables above are the attributes of Category B4. According to the Local Government Handbook (2019), the number of dysfunctional municipalities in South Africa has risen from 64 to 66, despite the efforts by MISA and COGTA to intensify infrastructure

management support in municipality. A further attribute is the municipality's inability to produce own revenue from either property taxes and service fees apart from fiscal transfers from national governments. An additional characteristic of municipalities in Category B4 is Section 139 intervention under provincial executive oversight by CoGTA.

Section 139 of the Constitution impede municipalities' authority with the aim of to ensuring that municipalities provide essential services to communities within their jurisdictions. Municipalities across the country, including those in this study sample, have a dearth of appropriately accredited officials in the domains of civil, electrical, and mechanical engineers. Only 168 fully accredited engineers are appointed in municipalities around the country. This figure represents roughly 19% of the total of 1 026 employees appointed in engineering positions. In any given year, the municipalities struggle to spend or execute their MIG funding allocation.

4.8.3.4 Selection Strategy of Study Informants

Research was conducted in four municipalities chosen from among the twenty (26) municipalities in the North West and Eastern Cape that fall into the Category B4. Non-probability purposive sampling was undertaken to identify suitable research participants, and key informants (Guthrie, 2021).

According to Creswell (2018), purposive sampling strategies allow for deliberate selection of specific individuals, and settings to source knowledge that could otherwise be unobtainable elsewhere. The researcher included respondents or key informants in the sample, based on the belief that they warrant inclusion (Creswell, 2018).

Table 4.4: Selection Strategy of Study Informants

Selection strategy of study informants/subjects using purposive sampling				
Stage 1: Problem Analysis and project planning				
Selection criteria	**Municipality**	**Person (s) Identified**	**No of persons**	**Data Collection Techniques**
Incumbent position provides a high probability to attain accurate insight into the department's current strengths and gaps	Mhlonto LM Mnquma LM, Nyandeni LM, Moretele LM	Technical Directors	4	Interviews
Stage 2: Information gathering and Synthesis - Purposive Sampling				

Selection criteria	Municipality	Person (s) Identified	No of persons	Data Collection Techniques
Managers designated in the municipal service divisions	Municipalities sampled	Divisional Heads (Water, Roads and (Refuse removal	4	Semi-structured interviews
Practitioners responsible for municipal infrastructure support interventions	MISA National and Provincial (EC and NW)	National and Provincial Heads	2	Semi-structured interviews
Stage 3: Stage 3: Developing the conceptual framework				
Selection criteria	**Municipality/ Organisation**	**Person (s) Identified**	**No of persons**	**Data Collection Techniques**
Targeted audience of experts from the built environment	IMESA, SACPCMP, SAICE, MISA	Practitioners	4	Semi-structured interviews
Stage 4: Early development and Refining of the framework				
Experts in the built environment field	SACPCMP, SAICE	Expert Focus Group	2	Unstructured Interview

Source: Author

4.9 DEVELOPMENT OF THE RESEARCH INSTRUMENTS

After determining the target population, sampling frame, sampling method, and sample size, the next step was to collect data. The researcher used multi-qualitative data instruments, firstly a literature review, and semi-structured interviews process was followed to draw inspiration from the qualitative data, to get to the depth of the problem. Unstructured data was collected to get to the breadth of the problem by answering the following questions stemming from the reviewed literature on resilience, ES, and infrastructure management capabilities.

Table 4.5: Development of Research Instruments

Research Questions Stemming from Literature Review	Literature Review References
#1 How can resilient infrastructure management capabilities in Category B4 municipalities be developed?	(SEI, 2021) (WRC, 2019) (Mirti, 2018)
#2 What are the requisite capabilities towards improving infrastructure management resiliency in Category B4 municipalities?	(PMI, 2021) (Van de Walt, 2020) (MDB, 2019) (Park, 2021) (Lephoto and Khatleli, 2020)
Capabilities for Infrastructure management Resilience in the B4 category of municipalities	

2.1	Align planning, budgeting and infrastructure delivery cycles and value for money relating to infrastructure delivery	(Flyvbjerg, 2021) (Saunila, 2016) (Hassan and Faris, 2019) (GGA, 2021) (SACN, 2019) (Duchek, 2019) (SACN, 2019)
2.2	Engineering designs	
2.3	Determination on VOs in infrastructure projects based on scope planned and scope performed	
2.4	Estimate and negotiate project costs – controls	
2.5	Critical path project scheduling and project management processes	
2.6	Project management practices in monitoring project quality	
2.7	Planning and Acquisition life-cycle management	
2.8	Financial management and own revenue generation muscle	
2.9	Contracts management	
2.10	Stakeholders' communication and engagement	
#3 How can the project management capabilities to improve ES resilience be assessed in category B 4 municipalities ?		(Park, 2021) SEI, 2021
#4 What were the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities?		
# 5 How can improvement of infrastructure management capabilities be achieved in Category B4 municipalities?		Kerzner (2019) PMI (2017)

Source: Author

In summary, the descriptions of the population sampling method, data collection instrument used and participants involved in collecting data to answer the research question has been presented in table 4.6 below:

Table 4.6: Summary of data collection protocol

Questions	Population	Sampling Method	Instrument
How does the usage of project management approaches for managing infrastructure by current technical employees compare to the project management approaches employed by previously deployed support engineers?	SAICE Retired Engineers/Technical Directors	Purpose Sampling	Semi-sturctured interviews
What were the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities?	SAICE Retired Engineers/Incumbent Technical Directors	Purpose Sampling	Semi-sturctured interviews
How can the project management capabilities to improve ES resilience be assessed in category B 4 municipalities ?	Divisional Heads (Water, Sanitation, Roads and (Refuse removal) National and Provincial Heads: MISA Capacity Building Unit	Purpose Sampling	Unstructured interviews
What are the key areas for capacity improvement that should be included in the resilience framework?	Expert group	Purpose Sampling	Semi- structured interviews
How can the infastructure management improvement pathway in category B 4 municipalities be developed?	Expert group	Purpose Sampling	Unstructured interviews

Source: Author

4.10 TRUSTWORTHINESS OF STUDY

The reasonable generalization of data from a broader group is referred to as research population validity (Creswell, 2018). The validity of an inference depends on the form of inference, thus designing appropriate measurements and adequate assessment instruments directly impact on the validity of the study conclusions (Creswell, 2018). This is in recognition of the fact that validity does not refer to the truth of the premise or the conclusion, but rather to the form of an inference. The study included the following test measures to ensure validity:

4.10.1 Construct Validity

To achieve this, the researcher used multiple data sources. During the iterative processes of developing the framework, experts from the CIDB, SACPCMP, SAICE, and internal employees in the municipality participated in these focused sessions. There was a feedback loop established from these sessions and taking back to the respondents what had been said for validation purposes.

4.10.2 Internal Validity

Internal validity pertains to the relationship of variables employed in a study and the connectedness as a causal relationship between variables. The assumption (Section 2.7) was that a causal relationship exists between employee IM capability maturity that collectively sustains

organizational infrastructure management resilient capabilities. The assumption from the above is that the more mature an organisation is, the more likely the management of infrastructure is sustainable and project performance improved.

Study findings confirmed this assmption as engineering competencies in the fields of planning and design, as well as the use of technology to execute engineering work in the fields of construction, operations, and maintenance, were found to be insufficient in all four case study municipalities, beyond the support provided. The strategies outlined by Yin (2018) were used for ensuring internal validity in this study. These strategies included the use of explanation building with due consideration for similarities between patterns of intra-case and inter-case study findings, as well as opposing explanations. Professional questions relating to study aims and objectives were asked to achieve internal validity (Saunders et al., 2019). The trustworthiness criteria adopted along with the steps taken to fulfil the research findings is outlined in Table 3.7.

Table 4.7: Summary of Research Methods

Objectives	Research Methods	Sampling Method	Instrument	Data Analysis	Propositions/Questions
To compare the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel.	Qualitative	Purpose Sampling	Semi-sturctured interviews	Thematic analysis	By doing the research on how the usage of project management approaches for managing infrastructure by current technical employees compares to the project management approaches employed by previously deployed support engineers, we hope to delineate the desired practesthat shouldbe included as part of the ES improvement pathway
To identify the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities.	Qualitative	Purpose Sampling	Unstructured review	Thematic analysis	How can the project management capabilities to improve ES reslience be assessed in category B 4 municipalities ?
To identify the key improvement areas that should be incorporated in the resilient infrastructure management capabilities maturity framework.	Qualitative	Purpose Sampling	Unstructured review	Thematic analysis	What are the key areas for capacity improvement that should be included in the resilience framework?
To develop a resilient infrastructure management framework, drawn from capability maturity model for municipalities in category B4	Qualitative	Purpose Sampling	Unstructured review	Content analysis	How can the infastructure management improvement pathway in category B 4 municipalities be developed?

Source: Author

4.10.3 Reliability

Reliability deals with the robustness and consistency of the instruments administered at different times yet yielding consistent findings (Guthrie, 2021). This was achieved in this study by systematically documenting all the processes and procedures used in arriving at the research outcomes. Process documentation creates an opportunity for other parties to appraise the research (Creswell and Poth, 2018). Many researchers highlight the value of doing your own transcribing,

to build intimate knowledge of your data and starting the analytical process. The objective of documenting processes ensures that if another researcher were to conduct the same study all over again, the same findings and conclusions should be reached.

4.10.4 Personal Conflicts and Biases

Bryman and Bell (2021) consider these as a set of circumstances or conditions in which professional judgement of a primary interest, such as research integrity and quality, is unduly influenced by a secondary interest, such as personal financial gain. Personal conflicts can lead to bias in favour of a researcher's secondary interest, undermining the reliability of research results (Bryman and Bell, 2021). This was addressed by selecting an adequate quota sample size and employing a purposeful case study sampling strategy.

4.10.5 Procedural Bias

The researcher recognized that research bias allows readers to evaluate scientific literature critically and avoid suboptimal or potentially harmful treatments, whereas procedural bias occurs at any phase of the research process, including study design and data collection, as well as data analysis and publication. Interviewer bias, according to Bryman and Bell (2021), is the systematic difference on how the information is gathered, recorded, or interpreted. Selection bias may occur during the study population identification process. In avoiding procedural bias, the researcher avoided putting too much pressure on research respondents to get answers. Such reporting, that was first described in the conceptual framework of the study, was revisited just before reporting the work. The researcher made use of member-checking to refer data collected back to the research respondents to verify the results of the study (Creswell and Poth, 2018).

4.10.6 Confirmability

The concept of trust has recently received a lot of conceptual significance in research ethics context (Hendriks, Kienhues, and Bromme 2020). Researchers ought to demonstrate that their study findings are trustworthy and that there is good reason to believe they are true based on sufficient high-quality evidence, as a way of mitigating ethical concerns. Rather than imposing one's own assumptions, as Creswell (2018) posits, the researcher accommodated the research participants. Peels and Bouter (2021) say that study findings are reliable if they have been thoroughly tested and have not been disproven. In mitigating the trustworthiness risk, also known by some scholars (Guthrie, 2021) as the direct replication crisis, priority was given to the

development of strong theories and sharp premises, and which future conceptual replication studies may be found useful.

In dealing with research trustworthiness, this qualitative study necessitated the investigator's full participation in data analysis and interpretation, attributing credible meaning to it as purported by Hendriks, Kienhues, and Bromme (2020). From a qualitative perspective, trustworthiness is considered a more appropriate criterion for evaluating qualitative studies, in order to ensure the process is trustworthy.

In this study, the researcher accomplished trustworthiness by self-administering the interviews. Creswell (2018) describes the extent to which the research study's findings could well be confirmed by other researchers. The confirmability of the results is influenced by minimizing or explaining any researcher influence on the result by applying and meeting rigour criteria, such as member checking, triangulation, and peer review, all these were implemented by the researcher. Throughout the data collection processes, copies of the interview transcripts and all audio recordings were kept as proof of collected data.

4.11 ETHICAL RISKS AND MITIGATION STRATEGIES

Ethics in research entail the methodical analysis of moral behaviour. Ethical considerations have a special resonance in qualitative studies due to the general in-depth nature of the research process. During the data collection stage of the research, it remained critical to adhere to several such ethical considerations (Saunders, Lewis, and Thornhill, 2019). This section highlights inherent ethical risks and pitfalls that the researcher had to deal with. whilst conducting the study. The study took a precautionary ethics approach that recognized ethical obligations and employed ethically justified strategies to avoid any discordance with research participants.

4.11.1 Informed Consent

Sourcing informed consent is by nature problematic, and the researcher ought to be proactive in giving research participants the details about their liberty to participate and the intended purpose for data usage (Saunders, Lewis, and Thornhill, 2019). The process of obtaining consent consists of the following: voluntarily sourced consent, subjects should understand what is being asked of them, and involved persons must be competent to consent. The risk of harming study participants by exposing data that concerns them, remains at the heart of ethical arguments against qualitative data collection. This was mitigated by creating the respondent information sheet. Supplementary

to the information letters, written participant's consent to take part in this study was obtained only after a thorough explanation of the research process.

Respondents were given appropriate time to ask questions and address any concerns. The researcher also took time to explain that as their participation was voluntary, refusing to participate or withdrawal from the study while it was in progress, would not affect their jobs in the respective municipalities/organisations, in any way. The respondents then freely consented to participate in the study from a position of knowledge.

4.11.2 Anonymity and Confidentiality

These are critical in gaining access to the municipalities and, mainly, the individual respondents**.** The researcher took caution in protecting the identity of the respondents included in the study. The anonymity and confidentiality of the participants was preserved by not revealing their names and identity in the data collection, analysis and reporting of the study findings, however, anonymity was not easily kept during the interviews with experts. The researcher did not connect responses with the identity of the individual respondents when collecting data from officials in municipalities and the retired engineers who have worked with the municipality (Creswell, 2018). Non-disclosure of research subjects' identities protected them, and data obtained was utilized solely for study objectives. Data security was ensured between the researcher and the research supervisor. Privacy and confidentiality of the interview environment were managed carefully during telephone communication, interview session, data analysis and dissemination of the findings.

4.11.3 Avoidance of Harm

The ethical principle of beneficence, in its broadest sense and application, requires one to act in ways that are expected to continually create a significant alignment in, which the benefits of ethical research should outweigh the potential harm to participants (Creswell, 2018). Recently, the local government sector in South Africa has attracted government coalitions after the 2021 local government elections. The qualitative researcher was aware of potential harm that can be imposed on the participants. Thus, it became important to ensure that these ethical principles are applied throughout all stages of the research process, thereby balancing the potential risks of research against the likely benefit.

Given the volume of data generated and the pressurized project timelines, the services of an external professional transcription company specializing in audio file transcription were sought. When it came to professional transcribers, researchers have to think about one‘s ethical obligations to *'do no harm.*' Many researchers stress the importance of doing their own transcribing to gain intimate knowledge of the data and begin the analytical process. The researcher made every effort to minimise possible harm to the research informants as transcribing formed part of ‘*the duty of care’* that the researcher owed to research participants.

4.12 SUMMARY

The goal of this chapter was to outline and discuss several research paradigms, and critically examine the methodology appropriate for this research. The introductory section presented a brief overview of this chapter. This research methodology section of this chapter is structured using Saunders et al. Research Onion Model (Saunders et al., 2016). The Organizational Project Management (OPM3) maturity model serves as the foundation for this study's theoretical inclination. The model is designed to help organisations assess the state of their organisational project management maturity. An organisation's project management capabilities are assessed as they progress through the five degrees of maturity.

Based on the PMBOK knowledge management areas of project management, the framework should be able to identify and prioritize those project management capabilities that need to be improved to move through the stages. In the context of OPM3, a best practice is regarded to be accomplished when an organization displays consistent organizational PM processes, as indicated by its combined capabilities and productive results. The OPM3's principle of continuous improvement calls for organisations to recognize the need to frequently evaluate their project management maturity. Reliable systems and processes increase the likelihood of success but do not ensure it. In general, a best practice is deemed to exist when all its mentioned capabilities are present.

Among the topics discussed in relation to the aim of this study is research design, this entails research philosophy, approach, strategy, as well as methodological choices, time horizon and research techniques adopted in the study. Also discussed are the relevant theories, discussion on the application of expert forum review and case studies in this research. Discussions in the chapter ended with the presentation of data collection and analysis methods, as well as measures for overcoming some research challenges.

CHAPTER 5: PRESENTATION OF RESEARCH DATA AND DATA ANALYSIS

5.1 INTRODUCTION

Presented in this chapter are the case study municipalities (Mhlontlo, uMzimvubu, Nyandeni, Mnquma located in the Eastern Cape, and Moretele in the North West Provinces of South Africa). The case study selection criteria used to identify these two provinces is discussed in detail. The researcher included cases in the sample because they are thought to be relevant. The Eastern Cape and North West Provinces were selected as case study provinces representative of the precise attributes of the Category B4 municipalities under enquiry.

These provinces with similar traits were grouped together to ensure that at least one of those groupings was represented in the research sample as specified. This chapter begins by providing background information to the four case study municipalities, including the demographics and service provision capabilities. Subsequently, data from the case study municipalities is analysed. The analysis section assesses the data in relation to the reality it reflects, with regard to the research questions that served as the basis of this research, and relative to the data itself to determine whether the evidence supports the postulations that underlie the research questions. The contextual justifications and analytical techniques used by the researcher to analyse the social phenomena from multiple case study municipalities are also presented in this chapter (Renz et al., 2018).

5.2 PRESENTATION OF CASE STUDIES

Multi-case studies according to Yin (2018) have the advantage of replication reasoning, which may lead to better evidence robustness. The multi-cases in this study served that purpose. Denzin and Lincoln (2018) define project scope as the parameters within which the study enquiry is carried out. The scope of enquiry was confined to the four case study municipalities in the population of interest in the provinces of the Northwest and Eastern Cape. Case study evidence was collected from these four sites that met the sampling criteria and features of the Category B4 municipalities in these provinces. Full details on these characteristics according to the (MDB, 2018; LGSETA, 2018; National Treasury, 2018) are presented in the literature review.

5.2.1 Case Study 1 - Mhlontlo Local Municipality

Mhlontlo Local Municipality is one of the five Category B4 municipalities that make up the Eastern Cape Province's OR Tambo District Municipality. Founded in accordance with Section 12 of the Local Government Municipal Structures Act (Act 117 of 1998), the municipality incorporates Qumbu and Tsolo rural towns. The municipal area coverage is 282, 614 km2, and there are 73.3 inhabitants per km2. The municipality lies on the north-east side of the Eastern Cape provincial border alongside the N2 route between Mthatha and Mt Frere.

Figure 5.1*: Maps of Mhlontlo Municipality*

Source: *Adapted from Google Maps and Municipalities SA 2023*

The municipality's strategic location along the N2 national highway offers the local economy strong tourism and business opportunities. Natural resources, such as waterfalls, rivers, and dams, as well as heritage monuments and a diverse culture, abound throughout the municipality. Infrastructure development is critical to the economy and local government's success and service provision longevity. The municipality's rural nature has a considerable impact on the supply of basic infrastructure and services to all sections of the municipality (MDB, 2019). Infrastructure assets, such as water supply, sanitation, road and storm-water drainage, solid waste, energy supply, and community facilities, continue to be critical to the delivery of municipal services (IDMS, 2019).

Despite advances in delivering basic infrastructure and services in the Mhlontlo Local Municipality, significant backlogs continue. When analysing municipal performance in service provision, population figures are crucial since rising populations have a direct and indirect impact on infrastructure, employment rate and municipal revenue. The South African Constitution RSA (1996) outlines a system of local government and administration and mandates that each municipal council have a strong financial footing and predictable revenue sources to sustain its activities. Municipalities must maximize revenue collection from all constitutionally mandated revenue sources to guarantee municipal financial viability and sustainability, as well as resilient service delivery (IDMS, 2019).

5.2.2 Case Study 2 - Moretele Local Municipality

Situated in the province of the North West in a place called Moretele, Moretele local municipality, which has a 1 369 km 2 land area, was established in 2000. Moretele Local Municipality is one of the five local municipalities in the Bojanala Platinum District in the North West (as shown in

the map in Figure 5.2). It is the smallest of the five municipalities that make up the district, accounting for 8% of its geographical area.

Figure 5.2: Moretele Municipality Locality Map

Source: Adapted from Google Maps and Municipalities SA 2023

An international border divides the North West Province of South Africa from Botswana in the north. There are 66 villages and plots grouped into 24 wards in Moretele Local municipality (MLM) and the four traditional leaders approved by the law, rule the majority of the villages, and serve their respective communities in the council body. The municipality's administrative centre is located in Mathibestad, a settlement next to Makapanstad. The village of Makapanstad is situated in the middle of the Moretele area. On either side of the Makapanstad Road, there are communities that encompass the village of Mathibestad. The population of Moretele is 186 947, with population density of 136 people per square kilometre and an average household size of 3.4. There are discrepancies in poverty and unemployment throughout a number of areas.

Several local communities experience different levels of poverty and unemployment, with Moretele seeing 45% unemployment on average compared to 39% in Bojanala District (Census, 2022). People of the Moretele region have similar access to infrastructure and services. Several communities do not have water standpipes, with the exception of the people of Carousel View Village who do so, because of their close proximity to the Carousel Hotel and Babelegi Industrial Park. More than 80% of people living in the Moretele rural areas rely on groundwater in the form of boreholes as their primary source of drinking water (IDP, 2019).

5.2.3 Case Study 3 – Nyandeni Local Municipality

Nyandeni Local Municipality is a Category B4 municipality nestled in the Eastern Cape Province's OR Tambo District. Nyandeni Local Municipality was established through the Municipal Demarcation Act No.27 of 1998 incorporating the two former rural governing constituencies of Libode and Ngqeleni. The two cities are divided into 31 wards that make up

the Nyandeni Local Municipality. It is bounded by King Sabata Dalindyebo in the west, Port St. Johns in the east, Mhlontlo in the north, and the Indian Ocean in the South. It is one of the five municipalities that makes up the OR Tambo district, which accounts for over a quarter of its overall area. Figure 4.3 shows the location of the municipality.

Figure 5.3: Nyandeni Municipality Locality Map

Source: *Adapted from Google Maps and Municipalities SA 2023*

A majority-rural municipality, Nyandeni has 79% of its households in traditional village-style communities and just over 20% in the formalized, urban settlements of Ngqeleni and Libode. Large tracts of unsurveyed lands that are governed by traditional authority are a major feature of the rural areas. According to Stats SA (2022), 90% of population is AmaMpondo, with a blend of white and Zulu speaking section of the population making up the remaining 10%. Until 1894, AmaMpondo were the only tribe left outside by the colonial administration. Mpondo people were seen as retrograde because they clung to traditional ways of living and continued to exist for years beyond the control of the colonial administration (SAHO, 2022). Because of their large terrain, the Mpondo people would accept refugees and form tribes as part of the Mpondo people, as was the case in Nyandeni rural settlements. The Nyandeni integrated development plan (IDP) revealed that there is still a significant backlog in service delivery, particularly in the areas of water, sanitation, and housing. For instance, just 10% of families have access to services that meet acceptable standards for sanitization, and only 4% have such access to potable water (StatsSA, 2022). What needs to be seen, is to what degree the Nyandeni local municipality can overcome these service delivery obstacles.

5.2.4 Case Study 4 - Mnquma Local Municipality

Mnquma municipality is a Category B4 municipality located in the south eastern part of the Eastern Cape Province under the jurisdiction of the Amathole District. It was established

following the reorganization of municipal regions in South Africa in 2000 by amalgamating the peri-urban and rural villages of former Butterworth, Ngqamakhwe and Kentani Councils. The municipality shares borders with three other local municipalities (Mbashe, Great Kei and Amahlathi) as depicted in Figure 4.4:

Figure 5.4: Mnquma Municipality Locality Map

Source: *Adapted from Google Maps and Municipalities SA 2023*

In 2021, Mnquma Local Municipality had a population of 244,000 making it the most populated local municipality in the Amatole District Municipality (IDP, 2020). The highest number of households with piped water inside the dwelling are situated in the district. In Mnquma municipality, households still obtain water via water carriers and tankers, rainwater, boreholes, dams, rivers and springs. According to the municipality's IDP (2020), drought has affected the municipality since the 2017/2018 fiscal year. Mnquma has an adequate supply of high-quality groundwater. Nevertheless, without proper sanitation, sewage discharge from pit latrines has a negative impact on water quality (IDP, 2020). There is no waste collection in rural areas due to lack of waste transfer stations and a lack of waste collection vehicles. According to Stats SA (2021), only 19.70% of the households had their refuse removed weekly by the authority. The electrical infrastructure for street lighting is generally decrepit and needs urgent repair, with illegal connections compounding the problem.

5.2.5 Summary

A brief background of the case study municipalities was discussed in this section. The Constitution specifies guidelines for local government service supply. The primary services include water, sanitation, roads and stormwater, and garbage removal. As they struggle to recruit and retain competent engineers to improve service delivery, municipalities in Category B4 want

to increase their unique competencies to perform in a competitive local government market. The section below presents the data collected from interviews conducted.

5.3 ANALYSIS OF TRANSCRIBED DATA

5.3.1 Introduction to the data analysis

The qualitative analysis of data to discover themes went from identifying codes to constructing themes by combining codes based on shared case study features. The researcher carried out repetitive data reading to become acquainted with the data from the respondents' interview transcripts, where patterns and themes were discovered. Each main subject, as well as related subthemes and categories (where applicable) were presented and corroborated by direct quotes from interview transcripts. The identified themes, subthemes, and categories as well as the supporting stories from the transcripts were compared to the existing body of knowledge. The themes were generated in the discussion areas which include the following: challenges encountered in addressing service backlogs; usage of standard project management practices in managing infrastructure between erstwhile supporting engineers and the current technical employees in case study municipalities; key knowledge areas are associated with building resilient infrastructure management capabilities and critical improvement areas to be strengthened in rural Category B4 municipalities. These topics are covered in depth in the sections that follow. Analysis boxes were the used to summarise the responses to answering the research question and to provide significant themes related to the research problem.

5.3.1.1 Theme 1: Challenges in Addressing Infrastructure and Service Provision

As a result of the extended service coverage to more communities in the new South Africa, service provision backlogs were enormous in previously unserved rural towns. These backlogs required technical managers that are well-versed in all project management knowledge areas from planning, budgeting integration management, crucial component of infrastructure management. Managing stakeholders, entails overseeing the processes used to bring together various project components. When questioned about how infrastructure planning and budget alignment processes were synergistic to South Africa's legislative infrastructure delivery management system (IDMS), technical managers had this to say, taking the lead in the planning process; however, public participation and community consultation are still an important element of the

process. Despite the progress made in responding to basic service supply, infrastructure planning has been difficult due to low human and financial capacity in rural communities.

5.3.1.1.1 Sub-Theme - Pre-Planning Phase

Public participation is a preparatory phase that occurs before infrastructure planning and implementation. According to the participant 'accounts, public participation should take precedence via door-to-door visits, ward committee meetings, and council outreaches in order to acquire a sense of the community's needs. Some participants reported doing infrastructure services assessments through questionnaires, which limits probing community requirements, whereas others relied solely on IDP road shows and community *imbizo* to inform communities about municipal plans and programmes.

The technical directors' responses are represented in the following storylines:

"We begin by consulting with the community to determine their needs and which of their challenges we can address."[ES1- Mhl]

"The IDP unit in collaboration with the Speaker's Office is in charge of the IDP roadshows, community izimbizo undertaken to identify community needs." [DPlan – Mhl]

"Municipalities use MISA infrastructure assessments to assist in meeting community expectations." [ES2 – Nyan]

"Once the quarterly reports are issued, the statistics on the backlog figures are given in order to benefit the community." [ES 3- Mnquma]

When asked about the municipalities' approach to community involvement in infrastructure construction and management, the officer described the challenge as the impediment to the implementation of the infrastructure:

"Inadequate public participation is a serious issue that impedes the municipalities" planning and implementation of the IDP." [IDP Officer].

In South African local government, the concept of '*building communities together'* seeks to develop more cohesive communities, minimise inequities, and make government more responsive to the needs of communities (Local Government Handbook).

IDMS established a holistic approach to the complicated challenge of infrastructure delivery and management as opposed to the traditional recurring governmental policies. What was found in the case study municipalities is that the use of a top-down approach remains prevalent, despite the introduction of the local government IDP policy on community participation. When the municipalities are identifying priority local service provision issues, the planning of infrastructure programmes to be implemented is not done alongside communities. There was little evidence that the ward committees for planning undertake the following - gather information through various stakeholder engagement processes; assess community needs to gain an appreciation of the genuine felt need and provide feedback to the communities. The emphasis was also solely on informing the community about municipal projects in the pipeline, rather than providing a platform for community members to examine their reality or needs.

While the secondary documents related to the municipal infrastructure grant (MIG) highlight the importance of community participation. Further to the findings of this study, municipal IDP policies are well written and endorsed by Council, as evidenced by council resolutions shown to the researcher and the attendance registers of community IDP imbizo held to inform communities about projects that will be undertaken in a given financial year. Furthermore, what was found in the case study municipalities is that, as much as the project managers recognise the value of pre-planning, but they lack organisational capabilities and resources to properly involve communities.

The main challenge found is that the IDP's do not serve as a road map for where infrastructure services should be prioritised and delivered to address infrastructure backlogs in previously unserved rural communities. A key tenet of the integrated development planning is for the process to be deeply embedded in municipal decision-making, budget allocation, and infrastructure service delivery methods. However, in these rural towns IDP's were never considered as anything more than regulatory compliance.

5.3.1.2 Sub–Theme: Lifecycle Planning

Infrastructure has a life span. Many governments both at local and national level have significant challenges in ensuring optimal infrastructure performance throughout the asset life cycle. The life-cycle process of preserving an asset starts from needs assessment, planning, and budgeting to procurement, construction, operations and maintenance (ACSE, 2017).

One technical services director stated that the most significant lesson he learnt was the importance of life-cycle planning. He elaborated:

"*Infrastructure planning must be done on time as the first phase of the delivery cycle to properly match the budgeting cycle with the infrastructure delivery cycle. When it comes to infrastructure delivery, I have seen how poor planning and budgeting resulted in delays, unsatisfactory infrastructure that is not economical, or let me say adequate at reaching organisational objectives."* [ES4 – More]

Another technical director echoed that *"our municipality continue to have inadequate capacity in life-cycle infrastructure planning and budgeting, similar to other Category B4's experiencing the same problems.*" [ES2 – Nyan]

"Our internal project managers become irritated at not being able to complete the actual full value chain of engineering work beyond infrastructure project management duties." [MWS1, Moretele Local Municipality].

Confirming what was highlighted in Chapter 3, there is currently an investment gap in resilient future infrastructure. In managing infrastructure forecasting, the future performance of an asset should be based on investment scenarios and maintenance plans. Evidence suggests that the vast of infrastructure investments continue to be directed towards '*business-usual infrastructure'*. The traditional infrastructure planning strategy has been sectorial, top-down and non-participatory. It becomes important to strengthen the technical and institutional capacity of the Category B4 municipalities to adopt and apply integrated approaches to infrastructure planning by incorporating resilience and life-cycle management principles.

5.3.1.3 Sub-Theme: Budgeting

The budgeting process is regarded as the most crucial function impacting the effectiveness of infrastructure development especially for rural municipalities with lesser exposure to modern intricate budgeting processes. This is supported by the following statements made by the technical directors.

"One of the most significant impediments to successful infrastructure delivery in here is meeting the budget target. Eish, without sounding too political about budget availability, it is controversial to note that we are progressively allocated infrastructure development and maintenance responsibilities, yet we are still entirely reliant on financial transfers from the National Treasury". [ES1- Mhl]

"Failure to realise the budget implications of procedures that occur outside of the actual construction activities is one of the most major barriers to successful infrastructure delivery (meeting schedule, cost, and quality standards) ". [ES4 – More]

"Once infrastructure designs are completed, the following step is to ensure that it (project) is funded, delivered on time, and stays within the budgetary restrictions of the project." [ES2 – Nyan]

It is evident from the above findings that municipalities must still be assisted in incorporating the identified infrastructure projects into regular planning and budgeting procedures. Thus, aligning planning, budgeting and infrastructure delivery cycles and providing value for money relating to municipal infrastructure delivery.

5.3.1.4 Sub-Theme: Procurement

In addition to infrastructure deficits in Category B4 municipalities, infrastructure procurement is plagued with difficulties, including procurement capability inadequacies. Public-sector infrastructure procurement should achieve essential procurement objectives such as sustainability, value for money, transparency, and accountability. The capacity of the municipalities' supply chain management departments is key to accomplishing these procurement goals. The respondent's opinion on the adequacy of infrastructure procurement capacity in the case study municipalities was determined using a 5-point Likert scale (1 = very inadequate, 2 = inadequate, 3 slightly adequate, 4 = adequate, and 5 = very adequate). The rating was based on the following major organisational procurement capacity areas: organisational structure; staffing profile; budgeting and planning process; and whether appropriate capacity exists to effectively achieve infrastructure procurement objectives.

Table 5.1: Adequacy of Infrastructure Procurement Capacity: Organisational Structure

Respondent n	**5-Point Scale (1-5)**
Mhlontlo	Very Inadequate
Moretele	Slightly Inadequate
Mnquma	Inadequate
Nyandeni	Inadequate

Source: Author

Table 5.2: Adequacy of Infrastructure Procurement Capacity: Staffing Profile

Respondent n	**5-Point Scale (1-5)**
Mhlontlo	Inadequate
Moretele	Inadequate
Mnquma	Inadequate
Nyandeni	Inadequate

Source: Author

Table 5.3: Adequacy of Infrastructure Procurement Capacity: Budget and Planning Process

Respondent n	**5-Point Scale (1-5)**
Mhlontlo	Inadequate
Moretele	Slightly Inadequate
Mnquma	Inadequate
Nyandeni	Very Inadequate

Source: Author

5.3.1.5 Sub-Theme: Construction

This is the stage where all of the planning done will pay off. This stage focuses on performing quality control inspections, tracking effort and costs to determine whether the budget is on track, responding to requests for information (RFI's), ensuring that the architect, contractor and consultants deliver the project as designed. The unpredictability associated with human performance in the building of infrastructure projects is an inescapable source of risk during the construction phase (SAICE, 2020). Risks related with on-site building activities are among the infrastructure implementation challenges (IDMS, 2019). Divisional heads were asked how they manage construction throughout an infrastructure project's life cycle:

"We still utilise a step-by-step approach for accomplishing work on time and within budget that was drawn by the previous MISA engineer placed in the municipality." [ES 1 – Mhl]

"With a suitable construction project management framework, we will be able to adhere to most recent rules and industry norms including the general conditions of contract (GCC)". [ES- 2 More]

"To ensure compliance, our critical focal area was to identify and analyse project-specific potential risks that could result in cost overruns and delays." [ES4 – More]

5.3.1.6 Sub-Theme 6: Operation and Maintenance

Once the infrastructure is developed and communities are being serviced, municipalities should adhere to their constitutional duties to maintain infrastructure and provide maintainable, operating, and well-planned municipal services. Technical directors were asked to give an account on the summary of all their technical, administrative, and managerial tasks aimed at keeping infrastructure in an excellent condition over the course of an infrastructure's life cycle.

The respondents emphasised the significance of involving other stakeholders in implementing the operations and maintenance programs of the municipality. They have the following to report in this regard:

"We realise that asset management decisions in engineering projects are critical for optimising the specified infrastructure capacity." Our municipality was able to fulfil its maintenance operations targets through period inspections, repairs, and replacements, as well as providing management with data on the causes of infrastructure system failures, throughout the period we had MISA support engineer assigned to support us." [ES2 – Nyan]

"Despite being aware of the realities of collapsing infrastructure, we didn't have the internal engineering knowledge to collect financial information on planned and unplanned preventative maintenance operations, such as capital and maintenance activity unit costs, failure impact, and current equivalent replacement prices." [ES4 – More]

"Engineering skills to acquire new data on infrastructure deterioration, dependability skills and breakdown mechanisms, as well as assess the impact of system failures on performance and costs while taking existing infrastructure service demands into account." [ES 1 – Mhl]

"Incompetent administration of municipal service maintenance, on the other hand, contributes towards poor service delivery." [ES3 – Mnq]

These findings suggest that municipalities should implement and support a systematic, comprehensive maintenance strategy that leverages the benefits of preventative, predictive, and corrective maintenance processes to improve equipment dependability, save money and improve service provision.

5.3.2 Theme 2: Standard Project Management Practices in Managing Infrastructure between Erstwhile Supporting Engineers and the Current Technical Employees

4.3.2.1 Use of Data Analysis Boxes

The section is structured around the main areas of knowledge analysis (KA), assessment analysis (AA) and critical improvement areas (CIA). Analysis boxes were used to describe the conclusions of the analysis from the project as it progressed. Further themes of standard critical improvement areas that should be included in the capability maturity framework were analysed to produce an overall story line of data through analytical insights (Yin, 2017; Renz et al., 2018). This approach to analysis was successfully applied by Jacobs (2020) in his doctoral thesis on Project Management Maturity. In Jacobs (2020), knowledge levels analysis (KLA), common procedures analysis (CPA), and continuous improvement analysis (CIA), among other things, were used to determine how institutionalized and positioned project management was inside the organization. The study by Jacobs (2021) was specifically focused on investigating the relationship between project success and project management maturity through a few chosen Centres of Excellence in Sub-Saharan African universities.

Jacob's study served as a great inspiration and a guide in deciding which specific analysis approach was appropriate, since in this research there are also important theoretical aspects that must be considered to develop the capability maturity framework for resilient infrastructure management.

5.3.2.2 Project Management Approaches for Managing Infrastructure Utilised by Previously Deployed Support Engineers Compared To Currently Employed Technical Employees

ANALYSING THE STANDARD PROJECT MANAGEMENT PRACTICES IN MANAGING INFRASTRUCTURE BETWEEN ERSTWHILE SUPPORTING ENGINEERS AND THE CURRENT TECHNICAL EMPLOYEES IN CASE STUDY MUNICIPALITIES

Represented in the interview responses across the four case studies is the general inconsistency in infrastructure project implementation between erstwhile supporting engineers and current technical employees in the municipalities. Despite the engineering support provided previously, there was still evidence of inappropriate skills, to deal with water, sanitation, waste removal backlogs and the state of road infrastructure. Beyond the support provided, engineering competencies in the fields of planning and design, as well as the use of technology to execute engineering work in the fields of construction, operations, and maintenance, were found to be insufficient in all four case study municipalities. Current technical employees demonstrated limited experience with writing tender specifications for the procurement of engineering and construction works, and evaluating the bids, construction management and quality control. Previously, supporting engineers were quite keen in their usage of standard methods for infrastructure management, such as acquisition, constructing, renewal, maintenance, and disposal that are critical in evaluating the assets' continued suitability, adequacy, and effectiveness. In

One Municipal Infrastructure Support Agency (MISA) employee who was interviewed had this to say to reinforce the history of the municipalities' capability to manage and maintain infrastructure:

"*As an engineer who was once deployed to support the municipality, I believe that reliable, repeatable, and predictable infrastructure delivery management systems are required for resilient infrastructure. Outside of support programmes, there is a growing understanding that young and/or inexperienced engineers need to have a wide range of interpersonal, system-building, and personal knowledge and abilities in order to work in real engineering teams and create and manage infrastructure services that meet societal objectives*." (MISA, NW Senior Engineer)

5.3.2.3 Theme 3: Key Knowledge Areas Associated with Building Resilient Infrastructure Management Capabilities in Rural Category B4 Municipalities

KNOWLEDGE LEVEL ANALYSIS (KLA) OF THE REQUISITE CAPABILITIES TOWARDS IMPROVING INFRASTRUCTURE MANAGEMENT RESILIENCY

Poor quality plans or a lack of pragmatic infrastructure plans had a significant influence on the sustainability of municipal service delivery to communities prior to getting MISA infrastructure planning support. In two of the case study municipalities, for example, infrastructure projects with less impact have been identified and implemented ahead of those that merit priority. This pointed to an unstructured strategy to improve infrastructure management during the life cycle phases of design, approval, implementation, and operation. Furthermore, due to equipment and machinery deficiencies, as well as skilled personnel in the technical department, the present emphasis is on preventative maintenance. In order to manage infrastructure, provide services, and maintain the water, electricity, solid waste, roads, and sanitation sectors, there was still heavy reliance on externally outsourced knowledge from consulting engineering firms. Provision of municipal roads, water and sanitation, solid waste and electrical infrastructure are all specialised engineering fields, regrettably, three of the municipal technical directors had no broad knowledge of infrastructure and thus unable to effectively guide and manage subordinate managers who typically have specific knowledge on the infrastructure services for which they are responsible. Water and wastewater management was the hardest area where knowledge was inadequate in all four case studies.

"*Eissh, truth be told, it was during the support provided through MISA that we appreciated the multi-disciplinary competencies (including technical and financial capabilities) that are essential for aggregating asset life cycle demands and enhanced practice models that improve service continuity and resilience. Only through the level of such requisite infrastructure life cycle knowledge that regular routine maintenance could be undertaken in this municipality*". [ES 3 – Mnq]

Interviewing the SAICE engineer that supported the municipality under the Back-to-Basics municipal support programme: He responded by saying,

"*With the current backlogs, the municipality requires support with capital and maintenance expenditure life-cycle planning, as well as infrastructure asset management. The municipality should have a portfolio of infrastructure programmes included in the approved MTEF budget to ensure that the infrastructure assets offer the needed level of service to communities at the lowest possible cost. The operation and maintenance of the infrastructure assets and the risks mitigation strategies associated with the suitably skills for the design, construction management, is not well appreciated in rural municipalities. Ideally the concept of continuous improvement, and performance targets should form an integral part of the engineering services department of the municipality"* (*SAICE, retired engineer*)

5.3.2.4 Theme 4: Critical Areas to be Strengthened to Establish Resilient Rural Category B4 Municipalities

CRITICAL IMPROVEMENT AREAS (CIA) ANALYSIS

Engineering life cycle and reliability-centred maintenance standard procedures are critical areas identified unanimously by all four case study municipalities. This will involve an understanding of the areas of weakness and what is required to reach maturity in project management expertise. Use of a life cycle management method to maximize the value of infrastructure assets is a critical area for improvement. These capabilities, knowledge and skills are required to support the emergence of a capability maturity framework suitable for our municipality. Noticeably, scope management was another emerging theme from the case studies. During the data collection process, each of the four case municipalities had projects under construction and therefore it was easy to make reference to scope management in projects. In one case study MISA respondent indicated that when he first came to support the municipality, project files had no project briefs to contractors incorporating project scope definition and objectives to avoid cost omissions during budgeting. In another case study, critical area of improvement on scope management relates to infrastructure implementation issues including risks associated with on-site construction activities to ensure that deadlines are met, and risks of incomplete projects are addressed. There was no evidence showing that the municipalities were using standard templates for scope change control to manage change requests to prevent scope creep on project under construction.

Reliability-centred maintenance that seeks to develop a systematic, comprehensive maintenance strategy that utilizes the benefits of preventive, predictive maintenance was not adopted in the case study municipalities. Infrastructure planning, budgeting and delivery cycles, contract administration that are significant areas of development for every municipal technical department, need continuous improvement. Notwithstanding, asset management plans that incorporate a rigorous approach to maintaining infrastructure assets, the poor maintenance of assets continually results in inadequate and unreliable service delivery.

CRITICAL IMPROVEMENT AREAS (CIA) ANALYSIS - CONTINUED

It is critical for the local government sector to encourage infrastructure management practices that are consistent, repeatable, and reliable, according to established standards and regulatory requirements. The framework would ideally offer long-term predictability in infrastructure planning and delivery utilising life cycle plans, promoting standardization and uniformity in how municipalities should manage infrastructure assets.

Quality assurance remains one critical improvement area in monitoring construction quality and progress on control of scope and cost prior to payment certification. Supporting engineers made proper project choices regarding resources made at the construction sites to determine the entire time and cost schedules of a project. Evident from current personnel in the case study municipal technical department, there were construction quality audit reports to assure that construction contractors had higher labour productivity rates, finishing projects on time or ahead of schedule. Project resource decisions by support engineers included the preparation of procurement documents that played a significant role in tender evaluation, particularly when quality is part of the tender evaluation criteria, and in the activity level control of a project's total time and cost schedules, these are completely different from decisions taken by current technical directors. No quality assurance template to deal with infrastructure implementation issues which include risks associated with on-site construction.

Improving the reliability of municipal equipment and ensuring that municipal operations run safely and efficiently, necessitates asset management knowledge.

"This may be achievable only if our municipality would procure skills to deliver fewer shutdowns and better value for maintenance expenditures by shifting from a reactive to a proactive, reliability-focused maintenance strategy" (***MWS – Mhl***).

On the contrary, acquiring the additional capabilities focusing on precision maintenance and the minimization of rework was viewed with some sensitivity by tradespeople. The concern being their involvement might eventually lead to the workforce reduction.

5.4 DATA ANALYSIS

Choosing which facts about a reality to highlight and which theories to support them is a key step in the research process. Investigating and verifying knowledge are both goals of research (Alpi, 2019).

5.4.1 Research Analysis Overview

According to Creswell and Poth (2019), the analysis of data contributes and helps determine the logic that correlates the facts to the arguments. In analysing the data, according to Thelwell and Nelville (2021), the response rate was considered because each non-response had the potential to bias the total sample. The response rate of 67% has been based on the number of case studies drawn from the four municipalities, out of the six in the original sample of rural municipalities (Mnquma, Mhlontlo, Nyandeni, Moretele) who agreed to participate in the study.

These case study municipalities also served as units of analysis to examine the practiced attributes and routines for managing infrastructure by previously deployed support engineers. This is in addition to nurture resilience in varying infrastructure management capability maturity realities in Category B4 municipalities hidden in the data. Secondly, the analysis assesses the appropriateness of the project management capability maturity model (OPM3) in evaluating Category B4 municipalities' resilience in infrastructure management. The elements listed above serve as a template for developing the capability maturity framework for infrastructure

management resilience in Category B4 municipalities, and conceptualizing the resilience stage as the sixth layer of the OPM3.

Multiple case studies were conducted in order to acquire a better understanding of the critical areas for continuous infrastructure management improvement that will eventually be included in the capacity framework. The Category B4 municipalities represented in the case studies were classified based on their project management capabilities, and the framework was developed based on a five-level model. The motivation to use many case studies stems from a desire to reproduce the findings of a previous case with another instance.

According to Gehman et al. (2018), business studies researchers must constantly reassess their methodological collection in order to address any epistemological arguments about the extent to which fellow researchers, practitioners and policymakers can interpret the presented data and reach the same conclusions as the researcher for the presented qualitative research. Replication was used to confirm if the same or different findings will be obtained in different case studies (Yin, 2018). The analysis is set up so that it guides the reader through the earlier research studies on the scarcity of engineering skills, and its impact on service provision and the management of infrastructure (Lephoto, and Khatleli, 2020; Manu, 2019; Ntliziywana, 2017).

The basis for all the data is the transcripts of the interviews with 16 respondents, which were produced after 14 hours of interviewing. These were examined to identify any patterns or trends in the conclusions or findings. The use of triangulation was one of the key benefits of case study methodology used to acquire information from multiple sources to confirm the same findings.

5.4.2 Research Participant Demographics

Prior to giving the summary findings, the section describes the demographics of the participants and how they were identified. The full details of the participant's selection criteria are presented in Chapter 3. The technical directors in the engineering services department in municipalities divisional heads for water and sanitation, roads and stormwater and electrical, and MISA and SAICE deployees were among those who took part in the study. Some participants were chosen as they are the incumbents in the respective municipal engineering services and technical departments. Whilst other respondents from (MISA and SAICE) were included as informants because of their intimate knowledge of the infrastructure, as well as construction project management.

The gender, position, qualification, and years of experience of participants is outlined in the Figure 5.5 to follow. The researcher understood the need of preparing research participants for interviews, thus an invitation letter (see Appendixes) explaining the aim, nature of the research study, the entire data collection process, and the ethical concerns that required to be followed was sent to the identified participants. Those who agreed to participate in the study were asked to fill out informed consent forms.

Presented in Figure 5.5 is the demographic profile of the participants by position, qualification, years of work experience and gender.

Figure 5.5: Research Participant Demographics

Source: Author

The vast majority of responders have been in their positions for more than five years, while none of the current technical directors have more than ten years of experience on the job. This finding confirms the notion of failure to attract and retain capable technical expertise and experienced engineers, who are critical for continued service provision.

5.4.2.1 Sub-Theme: Technical Services Directorate Organogram and Positions

In olden days the town engineer, who had years of experience in local government, was the highest-ranking professionally registered technical official and a skilled engineer in charge of infrastructure in the municipality (Handbook, 2019). What was found is that the town engineer title has since been replaced by the technical services director who in many instances are not professionally registered with Engineering Council of South Africa (ECSA). The diagram depicts a hierarchy of technical employees that should be in place to handle infrastructure development, administration and operations, and maintenance in the municipality.

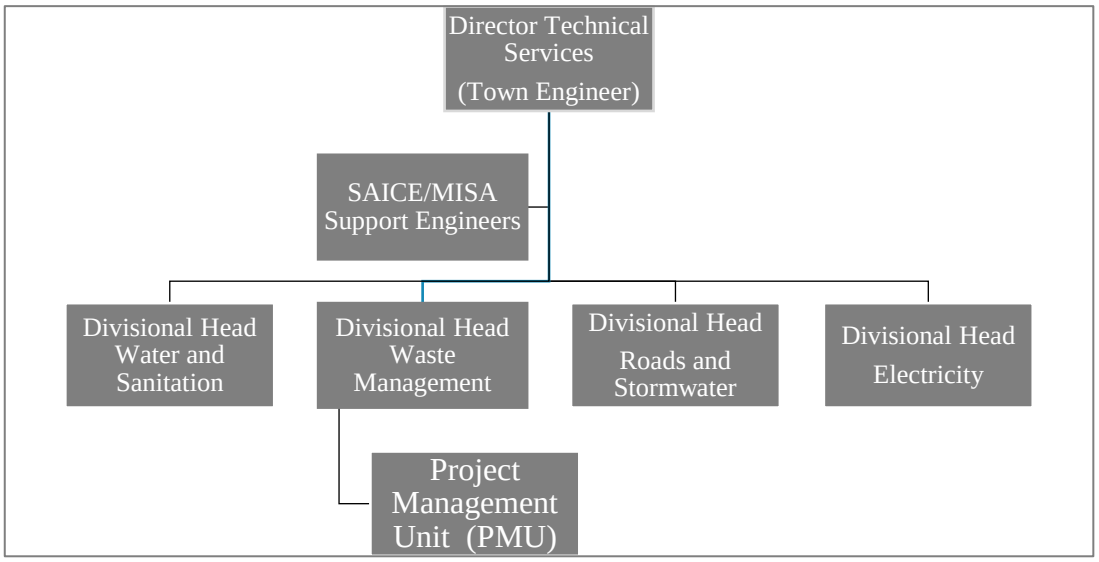


Figure 5.6*: *Technical Services Directorate Organogram

Source: Author

In the case study municipalities, none of the incumbent technical directors were registered with ECSA. It is not always common that the municipalities will have resident engineering support from either SAICE or MISA, where such is provided the support engineers would work with the office of the technical director.

The support engineers who participated in this study were the engineers that had previously provided support in the case study municipalities, there were no incumbent SAICE /MISA engineers during data collection. The divisional heads are expected to have the technical expertise to optimize the most effective and efficient collection and disposal of waste, as well as the sustainable provisioning of water, electricity, roads and stormwater respectively. However, because of the eroded technical capacity in the case study municipalities, the level of services provided had the worst impact on service provision.

5.4.2.2 Sub-Theme: Gender Distribution

In terms of gender demographics, there were five females and eleven males who participated in the study during data collection. According to this distribution, men at (70%) out-numbered women (30%) in the engineering services departments of the selected municipalities. This corroborates the gender inequality that persists in the engineering skills market, also confirming the statistics in the Lawless (2019) report on the needs and numbers of female engineers in the South African built environment sector.

5.4.2.3 Sub-Theme: Experience

At the time of this study the participants' experience ranged from five to twenty- two years. MISA and SAICE supporting engineers were the most knowledgeable and experienced research participants. The MISA engineers through the Technical Support Services program aims to increase the capabilities of municipalities for improved municipal infrastructure design, delivery, operations, and maintenance. Whilst the SAICE development project aim at strengthening the capacity for planning, delivery and maintenance of municipal infrastructure within municipalities. This is achieved by facilitating workplace opportunities in municipalities for graduates in technical disciplines and provide technical training for municipal officials. The support engineers that took part in this study were those who had previously provided engineering assistance in the case study municipality; there were no SAICE/MISA engineers present throughout data collection.

5.5 DOCUMENT ANALYSIS USING CONTENT ANALYSIS

Document analysis is particularly applicable to qualitative case studies (Creswell, 2018**).** In this study content analysis was utilized in analysing secondary data from documents. These documents included impact assessment reports of previous MISA engineering support programmes, PMI, the National Treasury quarterly reviews on the status of local government in South Africa and the Municipal Demarcation Board municipal assessment reports.

These documents have given background knowledge and historical perspective on the resilience or lack thereof, of the engineering skills support program to the chosen Category B4 municipalities. In addition, the National Treasury records, SAICE reports, and Municipal Demarcation Board (MDB) documents provides information and insight to help researchers

comprehend the historical foundations of infrastructure management capacities in Category B4 municipalities. In addition, the researcher used the information from documents to contextualize information gathered through interviews.

5.5.1 Purpose of Document Analysis

It is expected of the qualitative researcher to use multiple sources of evidence, for convergence and corroboration techniques. As a technique for triangulation, which combines methodologies in the study of the same phenomenon, document analysis in this study was used in conjunction with the other qualitative research methods (interviews). Possible biases that may exist in a single study is mitigated by the researcher's ability to corroborate findings across data sets and looking at information gathered through various data collection methods.

The researcher made a concerted effort to present a collection of credible evidence by triangulating data. As part of the case study, assessment report documents from the Municipal Demarcation Board, Municipal Infrastructure Investment Framework reports, National Treasury Quarterly documents and SAICE engineering support impact assessment reports were analysed to:

a) Help the researcher comprehend and gain new perspectives on the research subject.

b) Contextualize the information gathered during interviews using data taken from documents.

c) Offer supplemental research information.

5.5.2 Document Analysis Benefits and Limitations

In relation to other qualitative research methods, document analysis has both advantages and limitations. Let us look first at the benefits:

5.5.2.1 Document Analysis Benefits

a) ***Efficient method:*** Document analysis is less time-consuming and then more efficient than other research methods. It requires data selection, instead of data collection. The following steps were employed as part of the iterative data analysis process, through reading documents repeatedly to identify relevant data, building a coding frame comprised of main categories and sub-categories.

b) ***Accessibility:*** As many documents can be found in the public domain and downloaded without requiring author's permission, document analysis remains a popular strategy for qualitative researchers.

c) ***Stability:*** Documentation are suitable for recurrent reviews since the involvement of the researcher has no impact on what is being investigated.

5.5.2.2 Limitations of Document Analysis

Analysis of documents is not always beneficial. The following limitations are provided for noting:

a) Often fail to provide sufficient details to address a research inquiry.

b) Biased selection: the documents chosen are likely to reflect the priorities of the specific unit within the organization

These are more like minor shortcomings than major problems. Document analysis has benefits that, given its effectiveness and efficiency, far outweigh limitations. Hence the study used document analysis.

5.6 APPLICATION OF DOCUMENT ANALYSIS

Out of the 90 reviewed documents as part of literature review, 14 documents were selected to code the data. The initial coding of the document contents was based on three groups of search phrases such as:

1. SAICE/MISA engineering support in Category B4 municipality,
2. Sub-Theme (infrastructure management capabilities), and
3. Key words related to the sub-project (*capability maturity models, resilience, skills*, and so on), *engineering skills shortfall in South Africa', 'service provision in South African rural municipalities', 'infrastructure management in rural municipalities, 'capability maturity models', 'resilient infrastructure management capabilities'*.

The data analysis was prompted by constant comparisons methods, which was based on an inductive approach aimed at recognising patterns and revealing theoretical features in the data.

Elemental codes and notions were frequently verified and rechecked as the researcher interacted with data. Codes were grouped into substantive categories and compared across interview transcripts, participant feedback, and data from documents. Documents were particularly valuable in pre- and post-interview scenarios, in addition to adding context to the research.

Table 5.4: ***Documents Chosen for Sampling and Data Analysed***

Documents Selected	Data Analysed
Technical assistance for small towns and rural communities ***(ICMA, 2020)***	Data on previous engineering support programmes
Infrastructure procurement skills gap amongst procurement personnel in public sector ***(Manu et al., 2019)***	Data on the infrastructure acquisition lifecycle
Municipal Infrastructure Investment Framework - South African municipalities ***(MIIF, 2021)***	Importance of own revenue sources to attract skilled engineers
Empowering local government to make disaster resilient cities ***(Malalgoda, 2021)***	Data on critical areas to be strengthening for resilient infrastructure management
Relationship between OPM3 and Project management ***(Bento, 2019)***	Data on knowledge areas and capability areas
National Treasury standard for infrastructure procurement and delivery ***(IDMS, 2019)***	Planning and delivery utilising life-cycle plans
Financial Viability of rural municipalities in South Africa ***(Kanyane, 2021)***	Inability to attract and retain engineering skills
Water supply and sanitation services in small towns in rural-urban transition zones ***(Marks et al., 2020)***	Data on service delivery targets
Curbing cost overruns in infrastructure investment ***(Park, 2021)***	Importance scope and quality management
South African infrastructure conservations ***(SACN, 2019)***	Data on infrastructure management practices
Business models and dynamic capabilities ***(Teece, 2018)***	Data on infrastructure deterioration, dependability skills
OPM3 maturity model ***(PMI, 2019)***	Data on maturity levels and continuous improvement pathway
A contemporary twist on capacity enhancement ***(Brathwaite, 2018)***	Importance of the necessary capital, skills, and expertise to manage infrastructure
A confirmatory factor analysis of the challenges of effective management of construction workforce in South Africa ***(Aghimien et al., 2021)***	Data on to strength the capacity for planning, delivery and maintenance of municipal infrastructure

Source: Author

5.7 SUMMARY

The four case studies were carefully selected to yield an invaluable and deep understanding of the phenomena. Multiple case studies are preferred considering their contribution to support or contradict assumption, the more solid the research findings. The use of multiple case design frequently resulted in a more intriguing story, making the study more robust.

The researcher was aware that in qualitative case study research, the extent of engagement with the problem in question and the defined technique are far more significant than the number of cases under examination. Information from document analysis was categorized according to the research' main questions using content analysis. This involved a first pass document review, where pertinent and meaningful material was found. The established data findings were analysed, and capability improvement areas were confirmed utilising existing literature and the adopted theoretical frameworks. The analysis of the collected literature and research data is presented in Chapter 6.

CHAPTER 6: DISCUSSION AND INTERPRETATION OF FINDINGS

6.1 INTRODUCTION

This chapter follows the researcher's presentation of the cross-case study experiences in infrastructure management in Chapter 5, followed by the formation of an expert focus group to identify, discuss and validate critical infrastructure management capability areas that need improvement. The validated capability areas served as the gap-analysis and therefore the foundation for the development of a capability maturity framework for resilient infrastructure management in municipalities designated as B4. In literature (Aguinis and Solarino 2019; Creswell and Poth, 2019), expert knowledge can be obtained in a variety of ways, including the expert focus group, Delphi technique, expert interviews, expert panel review and nominal group technique. Among other researchers (Brathwaite, 2018; Bento, 2019; Chowdhury and Shil, 2021), the expert focus group technique has previously been used successfully.

In this study, the expert focus group of municipal engineering specialists was interviewed to validate the capability areas related to infrastructure management and to construct the recommended framework. The expert focus group enabled the collection of profound information from a team of four specialists followed by an expert panel's comprehensive qualitative examination of critical capabilities in order to close the gaps in the capability areas identified in previous studies. The processes involved in the identification and verification of capacity areas are explored in further detail in the next sections of this chapter, leading to the construction of the framework for capability maturity. The researcher studied various case studies to answer the research questions and have a better grasp of the phenomenon. Contrasts and similarities identified during data analysis both inside and across the Mnquma, Nyandeni, Moretele and Mhlontlo Category B4 municipal settings are discussed and further interpreted in the subsequent paragraphs.

6.1.1 How does the usage of project management approaches for managing infrastructure by current technical employees compare to the project management approached employed by previously deployed support engineers

Infrastructure management demands a clear vision that allows all parties involved to understand the end goal from the beginning. Over the years, these four case study municipalities were once beneficiaries of either the SAICE, MISA and or DBSA capacity building programmes. Effective leadership and governance by previously deployed support engineers has been observed in the way municipal projects were procured, planned, executed, and overseen, in order to create a

platform for successful infrastructure delivery. Senior engineers typically created an enabling environment in the municipalities they supported. This environment entailed a clear project management structure and assigned responsibilities within which decisions and authorizations to advance projects in an efficient and effective manner were made. In interpreting the findings from the case study municipalities, it became evident that varying project management approaches were employed in managing infrastructure projects, as discussed below.

The approach to managing infrastructure, based on project resourcing decisions made by support engineers was centred on value for money and high-quality service delivery from procurement to implementation. Infrastructure resourcing decisions began with the drafting of procurement documents, taking cognisance of experience in construction quality competencies as part of the tender evaluation criteria. Once the contractor is appointed, the support engineers took quality assurance seriously by monitoring construction quality and progress on scope and undertaking budget controls prior to certifying payments to contractors. Supporting engineers made proper project choices regarding resources at the construction sites, including determining the entire time and project cost schedules.

Unlike today's Mnquma technical department where some projects are completed after their scheduled completion date, the senior engineers that supported the municipality, were able to check that contractors had higher productivity rates in construction sites, completing the projects on time or ahead of schedule. Notwithstanding the required management of priorities between cost, time, and quality, currently, the municipality requires focused attention in providing critical direction for project delivery when difficult decisions must be made.

Despite previous engineering assistance, the study found that there was still evident shortages of adequate project management capabilities to integrate infrastructure planning budgeting, and infrastructure delivery and maintenance cycles to deal with waste removal and road infrastructure backlogs. Best practice project management is rather compromised with the current technical employees due to limited understanding of the infrastructure planning framework, design and execution of infrastructure projects, including the tracking of such projects and the monitoring of performance of appointed contractors.

Similar to Mnquma municipality, during data collection in Mhlontlo, there was mention of unfinished road construction projects, due to contractor non-performance. The senior engineers who assisted the municipality used project management approaches that aligned infrastructure

projects with municipal priorities, budgets, and plan. These plans clearly defined the objectives and expected outcomes, as well as parameters, such as timelines, cost, during planning phase. This defined the value-for-money proposal that must be implemented when the decision to proceed with a project is made. On the contrary, the current technical personnel were unfamiliar with the implementation plans, for either new infrastructure or maintenance of existing infrastructure that are in accordance with the recognized standard infrastructure delivery and procurement strategy.

Lastly, it was observed that the municipality is not immune to the so-called '*political deployees'* who were inexperienced non-registered technicians, who are also unregistrable individuals appointed outside the regulatory rules of the Engineering Professionals Act of 2000. What made matters worse was the transfer of critical responsibilities from the technical director's office to the Municipal Manager's office, which substantially reduced the engineering as well as project management services responsibilities of the incumbent technical manager.

6.2.2 Important Areas for Capacity Improvement to be Included in the Resilience Framework

6.2.2.1 Procurement and Planning

Procurement and planning of new construction projects were a common thread in all four case study municipalities. Infrastructure procurement is typically based on general terms of contract (GCC), which codify risk allocation for the contracting parties in relation to construction performance, timelines, construction guarantees, insurances, errors, and payments. The client municipality may opt between a fixed-price contract, which requires highly precise and specialized technical paperwork from the contractor in the tender, incentive arrangements contracts, or cost-reimbursement contracts, which place less emphasis on financial factors. As a result, selecting proper procurement options remains a critical component of project delivery. Consistent, repeatable, and reliable project management practices, according to established project management standards and regulatory requirements were key improvement area mentioned during the interviews.

6.2.2.2 Infrastructure Budgeting, Delivery and Maintenance Cycles

The process followed to deal with service backlogs was common in two of the case study municipalities (Mhlontlo and Nyandeni). Their service delivery budget implementation plans (SDBIP) were fully populated, except the lean maintenance budgets, which they subscribed to poor own revenue. However, Moretele lacked the expertise to develop an infrastructure plan that

identifies long-term requirements. Also, the municipality displayed no capabilities to optimize infrastructure maintenance, and relating those needs to a budget plan for the medium term-expenditure framework. Lifecycle management method to maximize the value of infrastructure assets was another key improvement area emphasised.

6.2.2.3 Quality Management

In Mhlontlo, it was found that there is no standard quality control plan audit for projects under construction. Similarly, Moretele systematic, quality audit processes were not documented, though there was mention of such processes during data collected. A number of projects in Mnquma were reported to have non-conformities and re-work discovered during project quality evaluations.

6.2.3 Practiced Attributes and Routines for Managing Infrastructure by Previously Deployed Support Engineers and Service Provision Resilience Nurturing in B4 Municipalities

The support engineers had totally different focus areas, as seen by the routines they practiced during their deployment in Category B 4 municipalities. A cross-case study inquiry also revealed some parallels in the areas of support. The deteriorating condition of infrastructure has become a more prevalent problem in many rural communities. Routine maintenance, preventative maintenance, and asset management, as formerly done by deployed support engineers, are crucial for improving municipal service provision resilience.

Poor quality plans or a lack of pragmatic infrastructure plans had a significant influence on the sustainability of municipal service delivery, with the multi-disciplinary competencies of support engineers (including technical and financial capabilities) that are essential for aggregating asset life cycle demands and enhanced practice models that improve service continuity and resilience.

The practiced routine of ensuring higher labour productivity rates and quality construction works of appointed contractors. In contrast to long-term contracts, short-term contracts make it easier to renegotiate the first-period offer to the benefit of the client municipality. Quality assurance audits also brought value in nurturing resilient service provision. With their effective management tools in place at all stages of the life cycle of the municipal infrastructure asset, the support engineers oversaw planning, prioritization, budgeting to design, procurement, construction, operation and maintenance. Requisite infrastructure life cycle knowledge of support engineers nurtured service provision in Category B4 municipalities.

Unfortunately, the enhanced levels of service provision were only visible during the years that the municipality was receiving technical support form MISA.

6.2.4 Design Factors for a Capacity Maturity Framework for B4 Municipalities' Infrastructure Management Resilience

The foundation of project management maturity is project management knowledge (PMI, 2021). As discussed in Chapter 4, the PMBOK knowledge areas are deemed appropriate design factors to contribute to the capacity maturity framework, while the OPM3 levels are designed to assist organizations in identifying the levels for capability maturity and continuous improvement pathway necessary to increase the organisational maturity in Category B4. Project management maturity is an organisation's ability to successfully manage projects using a standardised practise that has been improved and enhanced over time. As an organisation's project management maturity grows, municipalities became more capable of identifying areas for change that can improve project performance.

During data collection, the informants displayed some abilities to effectively detect project risks and willingness to improve accuracy of project estimates, optimising resource allocation, and strengthening stakeholder participation. In this research study, the capability areas found in literature were mapped against the PMBOK knowledge areas prior to being verified with the expert group, as depicted in Table 6.1.

Table 5.1: Mapping of Knowledge Areas against Capability Area

Knowledge Areas	**Capability Area**
Integration Management	Alignment of planning, budgeting and infrastructure delivery cycles and providing value for money in relation to infrastructure delivery
Scope Management	Determination on VOs in infrastructure projects based on scope planned and scope performed
Schedule Management	Critical path project scheduling and project management processes
Cost Management	Negotiated project costs Cost management controls
Procurement Management	Development of procurement documentation
Quality Management	Construction Management and Construction Quality audits
Resource Management	Infrastructure planning
Risk Management	Risk reduction, risk transfer, risk retention and risk mitigation strategies

Source: Author

Measuring project management implementation maturity can provide a useful foundation for performance improvement. This was accomplished by measuring the level of maturity of project management processes within these municipalities and identifying determinants (capability areas) influencing performance.

6.3 FORMATION OF EXPERT FOCUS GROUP

6.3.1 The Process

A focus group of experts was set up to explore the significance of the essential capacity areas that should be included in the capability maturity framework. The goal of the four- member focus group, which was led by a senior engineer from the SAICE development projects, was to provide relevant insights on the topic and verify the capability areas necessary for resilient infrastructure management in Category B4 municipalities. The following criteria were used to choose respondents for the verification process:

a) Participant must be accustomed to infrastructure management and be a professional in the built environment,

b) Must have previously been a support engineer deployed in the rural municipality,

c) Must have 20 years or more in the built environment experience.

6.3.2 Credentials of the Expert Members

In accordance to the informants' academic qualifications, two out of the five have a Master's degree, two have a Doctorate degree, and one has an entry-level degree. All the respondents had expertise in their respective sectors of civil and urban planning, ranging from 20 to 38 years.

Table 6.2: Credentials of Verification Experts

#	Designation	Sector	Qualification	Years of Experience
1	SAICE Consultant	Local government	MSC Civil Engineering	26
2	MISA	Private Consulting	MSC Civil Engineering	20
3	CEO SAICE Dev projects	SAICE Dev Projects	PhD Civil Eng.	38
4	Consulting engineer	Private	PhD electrical engineer	30
5	SACPCMP - moderator	Private	BSc Constr. Management	22

Source: Author

6.3.3 Instrument Design for Verification

The focus group discussion sought to draw inspiration from the members' complex personal experiences and ideas on the development of the infrastructure framework within the local government sector through controlled interaction. In this study, the expert review portion of the framework was assessed using a questionnaire. The uniqueness of the responses demonstrated that these experts are professional and appropriate for the verification exercise. As a result, the outcome of the verification exercise was deemed credible. The next section presents an expert verification of the initial identification of capability areas.

6.4 EXPERT PANEL VERIFICATION OF KEY CAPABILITY AREAS

One of the objectives of this study is to investigate the key improvement areas that should be incorporated in the resilient infrastructure management capabilities maturity framework. All the similarities identified and grouped as knowledge gap themes, were listed as key capability areas that must be verified by the experts. The study's aim was to establish a process for developing resilient employee infrastructure management capabilities, which are required for assessing organizational resilience. The OPM3 acted as a basis for analysing employee capabilities and the organisational resilience, on which the organisation is dependent.

The expert focus group was created by a purposeful selection of certain persons from the built environment, based on the belief that they merit inclusion and possess knowledge that would otherwise be unavailable elsewhere. Capability areas were identified and verified to establish the appropriateness of the OPM3 maturity levels for achieving resilient infrastructure management in the Category B4 municipalities. The researcher used the expert connections obtained from previous municipal infrastructure management experiences, for verifying the maturity levels of the case studies in the relevant key capability areas and to inform the framework design process.

Table 6.3: Verification of Capability Improvement Areas

Code	Key Capability Areas of Improvement	Verification Outcome and Recommendation by Experts	Final Verified Capability area
KCAI-1	Alignment of planning, budgeting and infrastructure delivery cycles	Split into two improvement areas	-Alignment of planning, budgeting -Alignment of budgeting and infrastructure delivery cycles
KCIA-2	Procurement Management	Split into two areas Development of documentation and Procurement administration	-Development of Procurement documentation -Procurement Administration
KCIA-3	Scheduling management	Split into two capabilities	-Critical path project scheduling -Project management approaches
KCIA-4	Scope planned versus scope completed	No new recommendation	Scope planned versus scope completed
KCIA-5	Determination on scope and budget variation orders	No new recommendation	Determination on scope and budget variation orders
KCIA-6	Cost management	Split into two capability areas -Managing cost escalation costs due to design ambiguity -Value for money in relation to infrastructure delivered	-Managing cost escalation costs due to design ambiguity -Value for money in relation to infrastructure delivered
KCIA-7	Contract Management	Split into two improvement areas	- Compliance management - Risk and liability Management
KCIA-8	Quality Management	No new recommendation Construction Quality audits	Construction Quality audits
KCIA-9	Risk Management	Risk reduction, risk transfer, and risk mitigation strategies	Risk reduction, risk transfer, and risk mitigation strategies

Source: Author

Prior to handing over to the expert verification process, a total of nine competency areas were identified from the literature (see Table 5.1). During the verification process, the experts expressed the reason for changes effected as follows. **KCAI -1** SAICE expert emphasised that infrastructure planning is a process, not an event and it requires focused capabilities to deal with encumbrances, such as land availability, property ownership, and zoning rights are dealt with in planning infrastructure, as are records of environmental decisions, including the current status and estimated deadlines for elimination of these encumbrances. It is a highly iterative process that involves matching infrastructure demand to available resources while maintaining required service standards. Inability to develop an infrastructure plan that recognizes long-term needs and relates those needs to a budget for the next few years, is a reality in the Category B4 municipalities. Hence the recommendation that capability improvement area for aligning planning and budgeting should be a standalone.

The experts sensed the inclination of municipalities to focus more on infrastructure development and less on delivery cycle monitoring and evaluation, thus the recommendation was to have a capability area to improve and align budgets with infrastructure delivery cycles. The municipality's intended mix of infrastructure projects may not be viable in the first year or two of a delivery cycle over the medium-term expenditure framework (MTEF) due to prior current project obligations. Adjustments to the budget caused by changes in goals and objectives, on the other hand, can and should be impacted over time, with the MTEF clearly reflecting such shifts in strategy at least in the outer year. Many Category B4 municipalities' face significant challenges in infrastructure performance throughout the asset life cycle. Capabilities should be in place at all stages of the life cycle of municipal infrastructure assets, beginning with planning, prioritization, and finance and progressing to design, procurement, construction, operation and maintenance. Ensuring quality infrastructure performance over the asset life cycle is a major challenge for many Category B4 municipalities. Capabilities should be in place at all stages of municipal infrastructure asset's life cycle, starting with planning, prioritisation and funding, to the design, procurement, construction, operation, maintenance and decommissioning.

The second outcome of the expert verification process was on **KCIA-2** - proposed inclusion of contract administration capabilities to ensure that provisions for price adjustment for inflation, delay damages, non-performance penalties, corporate guarantee, performance bond, and retention are made. One participant in the expert group from SACPCMP posits that contract administration should be carried out in accordance with the approved bill of quantities from the start of the project to site practical completion and the expiry of the defect's liability and latent defects liability period. However, it is quite rare for municipal authorities to be acquainted with such contract data. Among the experts' broad observations, were the numerous regulations that must be followed throughout construction. Experts acknowledged that regulation and compliance management is a component of every sector. Municipalities have construction restrictions, which include policies, standards, safety rules, and audits that must be followed. Thus, **KCIA-6** should include both compliance management and risk management. Following the end of the expert verification process, the confirmed capability areas were used in a mapping effort to establish a capability maturity framework. Monitoring the implementation and operation of infrastructure assets is crucial to ensure that the asset fulfils its intended purpose, without delays and excess costs. For effective monitoring of whole-of-life performance, there should be a systematic collection, storage and management of relevant data over the asset life cycle, including value-for-

money evaluations. All respondents agreed that the additional capability improvement areas were adequate as recorded in Table 6.4.

Table 6.4: Verified Capability Improvement Areas

Code#	Key Capability Areas of Improvement
KCAI-1	Alignment of planning and budgeting
KCIA-2	Budget alignment and infrastructure delivery cycles
KCIA-3	Development of construction procurement documentation
KCIA-4	Procurement administration
KCIA-5	Value for money in relation to infrastructure delivery
KCIA-6	Cost management
KCIA -7	Scope planned versus scope performed
KCIA-8	Contract Management
KCIA-9	Risk and liability Management
KCIA-10	Compliance management
KCIA-11	Determination on scope and budget variation orders
KCIA-12	Construction quality audits
KCIA-13	Life cycle asset operation and management
KCIA -14	Risk reduction, risk transfer and risk mitigation strategies

Source: Author

6.4.1 Summary

In general, the findings confirmed the infrastructure management capability gaps in the Category B4 municipalities, whilst the analysis enhanced the understanding of a variety of information found during the data gathering period. The findings also conform to the literature and lend credibility to OPM3 as a template to identify the present ES capabilities in the Category B4 municipalities and map out the recommended improvement pathway towards resilience.

6.5 HOW TO DEVELOP A CAPABILITY MATURITY FRAMEWORK FOR RESILIENT INFRASTRUCTURE MANAGEMENT IN B4 MUNICIPALITIES

The framework development is presented as the most significant outcome of this study. The framework building process that commenced with the verification of capability areas based on literature and case studies, was discussed. The research findings revealed that once the engineering support is removed from the municipality, the municipal technical services department do not adapt or deal with infrastructure management. Municipalities continue to have insufficient capacities in capacities in life-cycle planning and budgeting, construction management, cost management controls, and operations and maintenance. These states of affairs have led to the development of the capability maturity framework for infrastructure management resilience in collaboration with the chosen experts.

The framework development process involves the creation of a conceptual model, including the mapping of key capacity areas to maturity levels, additional verification of capability areas, and refinement of capability level definitions.

The conceptual development of the framework has undergone several iterations with a few carefully chosen expert members. Prior to being subjected to a second round of verification by an expert team, the findings of each encounter were synthesized considering what is already known.

6.6 PRESENTATION OF THE CAPABILITY MATURITY FRAMEWORK FOR RESILIENT INFRASTRUCTURE MANAGEMENT

The study aimed to reduce the resilience skills gap in the management of infrastructure in the B4 municipal category, by effecting the six-level of resilience in the existing Organizational Project Management (OPM3)**.** Levels 1-5 of the framework present capabilities in a predefined format for assessing municipality's existing position and determining how to improve their capacities in the phenomenon of interest. The maturity levels are distinguished by a growing level of expertise.

- **Maturity Level 1 –** These are municipalities with deficient technical capabilities are associated with low-degree service provision.
- **Repeatable Maturity Level 2 -** Project management practices were not yet consistent, repeatable, and reliable, according to established project management standards and regulatory requirements.

- **Defined Maturity Level 3 –** This is characterized with standardized processes, patterns and key areas of improvement that are more refined and have similar traits.

- **Focused Performance Level 4 –** This focuses on continuous improvement of key capabilities for managing infrastructure portfolios, programmes, and projects, with the goal of achieving service provision objectives.

- **Continuous Improvement Level 5 –** Here, maturity level is reached once infrastructure projects are completed, municipal technical departments' continuous management of operational efficiency and maintenance of infrastructure has matured.

- **Resilience Level 6** - This research investigation claims that at this level, composite organizational capabilities and processes with a large investment in staff expertise to enhance resilience.

Looking at what has been done already by other researchers, every single one of the current maturity models provide the level of detail and variety of variables required to evaluate all elements of organisational project management implementation. Furthermore, from a practical standpoint, each of the instruments supporting these models is built on an extensive number of questions or items, the majority of which have never been verified for scientific reliability or validity. Nonetheless, OPM3 is one of the most well-known. Hence, the pattern matching approach proposed by Bouncken et al. (2021) was used to assess the required competence areas on different OPM3 levels to drive framework development.

In order to improve theory development, qualitative pattern matching approaches were used. Capability areas were assessed and verified with the experts using the OPM3 maturity levels. The idea being to use these progressive levels as an improvement for achieving resilient infrastructure management in the Category B4 municipalities.

6.7 REMARKS FROM EXPERTS ON MATURITY STAGE CLASSIFICATIONS

The experts felt that the maturity framework should be clear and easy to use for evaluating capability gaps and identify continuous improvement procedures to be pursued.

i. **Ad hoc Maturity Level 1** - The first step in understanding the relationship between municipal strategic planning and infrastructure budgets is to complete KCIA - 1. When

mapping out the knowledge areas against infrastructure management maturity levels in the Category B4 municipalities, the first step was to link the organisation's strategic priorities and the infrastructure planning. The knowledge to link infrastructure budgets to pipeline projects was rather limited in the case study municipalities', as noted during expert conversations.

ii. **Repeatable Maturity Level 2-** The experts were in agreement that the primary focus of this '*repeatable level'* was to impress upon self-restraint in deploying common project management practices. However, the municipality's engineering competencies in the common areas of construction, operations, and maintenance, were deemed inadequate without engineering support. Current technical workers should be encouraged to possess capabilities in the area of procurement management of engineering and construction work, analysing bids, construction management, and quality control.

iii. **Defined Level 3 -** Experts felt that standardized processes, patterns and key areas of improvement are more refined at this maturity level, have similar traits as the achieved Level 4, where the infrastructure delivery management skills are imparted.

iv. **Optimizing Level 5 -** Applying the OPM3 organizational project management capability process, the municipalities would hopefully continue the improvement path.

v. **Resilience Level 6 - Study Contribution to Academia -** The local government sector has always been on the lookout for research studies that will help with reclaiming resilient employee infrastructure management skills. The study aimed to reduce the resilience skills gap in the management of infrastructure in the B4 municipal category, by effecting the six-level of resilience in the existing Organisational Project Management (OPM3).

Table 6.5: Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities

Key Capability Improvement Areas (KCIA	Capility Maturity Levels					
	Level 1 Adhoc	Level 2 Repeatable	Level 3 Defined	Level 4 Managed	Level 5 Optimizing	Level 6 Resilience
Awareness and understanding of infrastructure management In the technical department, employees should be familiar with infrastructure management. Routine and preventative maintenance of infrastructure is required on a regular basis. Initial thought on capacity maturity models Understanding the ramifications of unreliable service provision for the municipality.	Since there is no consistent environment, no standard capability maturity improvement methods are applied.	Every division water, roads, and solid waste are all making efforts to improve, yet they are not shared.	Standard infrastructure delivery and procurement processes have been established.	Tasks are well known and supported by defined methodss of improvement	Important lessons obtained from past supporting engineers are documented and offered for use within the department.	Continuous ability to manage infrastructure and respond to community service provision and asset maintenance requirements, and ultimately the ability to manage recovery of the affected service delivery divisions beyond the support of engineers deployed in the municipality

6.8 CONCLUSION

The expert focus group enabled the collection of information from a team of four specialists followed by an expert panel's comprehensive qualitative examination of critical capabilities in order to close the gaps in the capability areas identified in previous studies. The researcher studied various case studies to answer the research questions and have a better grasp of the phenomenon. Contrasts and similarities identified during data analysis both inside and across the Mnquma, Nyandeni, Moretele and Mhlontlo Category B4 municipal settings were discussed. The research findings revealed that once the engineering support is removed from the municipality, the municipal technical services department do not adapt or deal with infrastructure management. Municipalities have insufficient capacities in capacities in life-cycle planning and budgeting, construction management, cost management controls, and operations and maintenance. This led to the development of the capability maturity framework for infrastructure management resilience, in collaboration with the experts. The framework development process involves the creation of a conceptual, which included the mapping of key capacity areas to maturity levels, additional verification of capability areas, and refinement of capability level definitions.

The study aimed to reduce the resilience skills gap in the management of infrastructure in the B4 municipal category, by effecting the six-level of resilience in the existing Organizational Project Management (OPM3). Levels 1-5 of the framework present capabilities in a predefined format

for assessing municipality's existing position and determining how to improve their capacities in the phenomenon of interest. The experts offered valuable advice for the municipalities to improve sustainability, resilience and ensure value-for-money.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

Presented in the previous chapter is the framework created through the literature review, analysis of four different studies and an expert panel verification process. This study demonstrated the theoretical significance of the capability framework for infrastructure management resilience, which had been developed specifically for rural Category B4 municipalities.

Multiple case studies considered the engineering skill challenges facing municipalities with a particular interest in service provision. Despite studies on the engineering skills gap in the construction industry, no recommended systematic capability maturity approach for addressing deficits in infrastructure management and maintaining reliable services in almost collapsed municipalities has been devised. Tweaking the existing CMM, this study introduced the sixth stage of the '*resilience component'*. The theoretical foundation of the OPM3 enabled the development of the capability maturity framework for resilient management in Category B4 municipalities. As part of the study methodical approach, 14 capability areas were included in the capability maturity framework for infrastructure management resilience and were verified by experts.

7.2 RESEARCH OBJECTIVES REVIEW

The objective of the study was to develop a capability maturity framework for infrastructure management resilience in Category B4 municipalities. A review of documentation, as well as semi-structured case study interviews, was used to obtain data in the four case studies. In this study, a qualitative, comprehensive enquiry was a more appropriate approach in evaluating the daily life phenomenon of infrastructure management capabilities of Category B4 municipalities. The study also incorporated qualitative data from semi-structured interview questions for inspiration, direction, and eliciting more information from a diverse spectrum of respondents, while unstructured and semi-structured interviews were used to acquire data to address the latter Objectives 2 - 5.

Table 7.1: Methods Used to Achieve Objectives

Methods used to achieve Research Objectives			
Objectives	Mapping PMBOK Knowledge areas Against Capability Areas	Interviews	Expert Verification
To compare the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel.	✓	✓	✓
To identify the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities.		✓	✓
To assess the maturity of Category B4 municipalities in infrastructure management using the capability maturity model (OPM3)		✓	✓
To identify the key improvement areas that should be incorporated in the resilient infrastructure management capabilities maturity framework.		✓	
To develop a resilient infrastructure management framework, drawn from capability maturity model for municipalities in category B4	✓	✓	✓

Source: Author

7.2.1 *Objective 1:* To compare the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existing technical personnel.

The first study objective was to compare the usage of standard project management practices in managing infrastructure between previously deployed support engineers in Category B4 municipalities and the existent technical personnel. In project management there are standards, bodies of knowledge and best practices. Semi structured interviews were conducted with previously deployed engineers to find out how they were using the PMBOK standard project management practices informed by the PMBOK knowledge areas in comparison with the current technical managers. The mapping the PMBOK knowledge areas in the case studies, enabled the researcher to confirm the widespread inconsistencies in the usage of standard project management practices during infrastructure project implementation, between former supporting engineers and current municipal technical workers. The findings on the usage of standard project management practices were then used to critique and the interpretation thereof was incorporated in the design of the new framework.

The second objective was to identify the skills in infrastructure management that were employed by previously deployed support engineers to maintain reliable service provision in Category B4 municipalities. Current technical workers displayed minimal experience with developing tender requirements, analysing bids, construction management, and quality control for the procurement of supplies, services, engineering, and construction work. Unlike modern technical department workers, support engineers were able to ensure that construction contractors had greater labour productivity rates, completing projects on time or ahead of schedule. Support engineers' project resource decisions, which included the production of procurement documentation, played a crucial role in tender evaluation, especially when quality is part of the tender evaluation criteria. This study recognized the significance of previously employed engineering experts in imparting skills and improving the infrastructure management capabilities of Category B4 municipalities. With their effective management tools in place at all stages of the life cycle of the municipal infrastructure asset, the support engineers oversaw planning, prioritization, budgeting to design, procurement, construction, operation and maintenance as a way of nurturing service provision. Requisite infrastructure life cycle knowledge of support engineers nurtured service provision in Category B4 municipalities. Apart from the assistance offered, the municipality's engineering competences in the domains of planning and design, as well as the use of technology to perform engineering tasks in the fields of construction, operations, and maintenance, were judged to be insufficient. Through the case studies and mapping exercise, this study was able to identify these routines and skills employed by previously deployed support engineers to maintain reliable service provision during their deployment in Category B4 municipalities. These are all the capability areas that were then included in the capability maturity framework.

The third objective was to assess the maturity of Category B4 municipalities in infrastructure management using the capability maturity model (OPM3). The Capability areas were assessed and verified with the experts using the OPM3 maturity levels. The idea being to use these progressive levels as an improvement for achieving resilient infrastructure management in the Category B4 municipalities.

The fourth study objective was '*To identify the key improvement areas that should be incorporated in the resilient infrastructure management capabilities maturity framework*.'. There are about 14 capability areas that were deemed appropriate for the development of a capability maturity framework for resilient infrastructure management.

Table 7:2 Capability Areas Appropriate for the Development of a Capability Maturity Framework

Code#	Key Capability Areas of Improvement	Integration with existing knowledge areas
KCAI-1	Alignment of planning and budgeting	Schedule Management
KCIA-2	Budget alignment and infrastructure delivery cycles	Project Budget Management
KCIA-3	Development of construction procurement documentation	Supply chain Management – *Capabilities to evaluate proposals against tenders*
KCIA-4	Procurement administration	Project Procurement Management
KCIA-5	Value for money in relation to infrastructure delivery	Effective allocation of resources to achieve the desired results
KCIA-6	Cost management	Project Cost Management – *capability to manage allocated budget*
KCIA -7	Scope planned versus scope performed	Project Scope Management
KCIA-8	Contract Management	Contract Management
KCIA-9	Liability Management	Project Guarantees- *realise that without construction guarantees, liability is high*
KCIA-10	Compliance management	Stakeholder Management – ***capability to sort all statutory requirements for EIA's WULA's***
KCIA-11	Determination on scope and budget variation orders	Cost control and budget determination- ***capability to measure cost against budget***
KCIA-12	Construction quality audits	Quality Management – ***capability to use quality control charts***
KCIA-13	Life cycle asset operation and management	Operation and Maintenance – ***capability to undertake life Cycle Cost analysis***
KCIA -14	Risk Management	Risk reduction, risk transfer, risk retention – ***capability to reduce project risks***

Source: Author

The third objective was to assess the appropriateness of the project management capability maturity model (OPM3) in assessing Category B4 municipalities' resilience in infrastructure management.

This study objective was accomplished since the OPM3 assisted in the identification and prioritization of the project management capability areas in the respective case study municipalities. The existing OPM3 maturity levels one through five were used to inductively

create knowledge and broadened generalizations in order to construct the hypothesized framework.

Following that, the pattern matching approach proposed by Bouncken et al. (2021) was used to identify the required competence areas on different OPM3 levels to drive framework development.

The fourth and the last objective was the development of a resilient infrastructure management framework, drawn from capability maturity models for municipalities in Category B4. The framework is presented in Chapter 5.

7.3 SYNTHESIS OF THE STUDY FINDINGS

7.3.1 What Have Other Researchers Done on Capability Maturity?

Johnson, Russo, and Schoonenboom (2017) believe that advances in knowledge must, in essence, be built on earlier work. While the researcher ought to determine the knowledge frontier on a specific topic by reviewing literature and contributing knowledge (Guthrie, 2021; Denzin and Lincoln, 2018). In the literature review in Chapter 2, the researcher reviewed numerous studies (Bento, 2019; Lawless, 2019; Duchek, 2019; Schriber, 2020; SACN, 2021; Aghimien et al., 2022) to determine what other researcher have written on engineering skills shortages in South Africa and Sub-Saharan countries, capability maturity models and resilient infrastructure management.

The literature review, according to Palmatier et al (2018) is a noble technique used to synthesize the research findings in order to present evidence on a meta-level and to indicate areas where further research is still needed.

Evident from the study findings (detailed in Chapter 2) is that Category B4 municipalities in South Africa lacked the infrastructure management resilience required to address service delivery challenges. As a result, the South African government has responded with a plethora of solutions, frameworks, and capacity-building programmes aimed at enhancing the resilience of the government's institutions (Duchek, 2019). Despite various SACN projects in South African cities on water, energy, and climate resilience, no solid systematic capacity maturity framework for resilient infrastructure management in Category B4 towns has emerged (SACN, 2021). The multi-case study used as a unit of analysis for this research and data collection methods used are consistent with previous studies. However, none of the interventions, with the exception of the

current study, have recommended and developed the capability maturity framework to continuously improve infrastructure management resilience in municipalities in Category B4.

7.3.2 What has the Study Achieved?

The study was successful in bridging the resilient infrastructure management skills gap in the B4 municipal Category by enacting the six-level of resilience that was never covered in the existing Organisational Project Management Maturity model (OPM3). The levels as per the existing model were outlined and the researcher began by making observations about elements of the existing OPM3 model. The researcher then went from those observations to broader generalisations about those observations in the multi case studies.

One of the goals of this research is to look into the important areas for improvement that should be included in the resilient infrastructure management capabilities maturity framework. The data collected was used to identify early trends on OPM3 levels to lead the inquiry, and found common themes used to explain and develop the municipalities' infrastructure management capability development levels. All of the commonalities discovered and categorised as knowledge gap topics were highlighted as significant capability areas were identified and verified by experts. Once the observations were translated into broader generalizations of context, the researcher analysed the similarities and differences between contexts and judged the extent to which the study results are transferrable to the environment, in this case, the B4 category municipalities.

The researcher used a bottom-up generative approach that focused on gaining information on existing maturity models leading to the modification of the OPM3 maturity model (PMI, 2017). So, by modifying the existing model, actors were able to interactively construct reality using the observations from the OPM3 model wherein the '*resilience gap'* was imminent. The organization's infrastructure management competencies were evaluated as they progressed through the six levels of maturity.

It should be noted that the goal of case study, whether single case or multiple case studies, is not to acquire statistical generalisation or evaluate their representativeness, but rather their detail (Yin, 2018). According to Yin (2018) case studies have a tendency to generalize to various contexts and situations. Yin (2018) further states that case studies are not intended to generalise from 'samples to universe, but rather build theoretical premises which function as a tool to make assertions about situations akin to the one being studied.

7.4 STUDY LIMITATIONS

7.4.1 Multi–Case Study Research

The evidence obtained by a multiple case study is robust and dependable, but it has limits. The multiple case study method is restricted to researching phenomena in specific circumstances and does not provide a comprehensive picture of a phenomenon. Considering multiple cases demands additional time, resources, and effort from the researcher, as well as the participants and stakeholders participating in the research. Researchers must acquire and analyse data from a variety of sources.

7.4.2 Access to Research Subjects and Delays in Obtaining Data

The researcher assumed ideal settings to access the enrolled study subjects to enable the generalizability of the findings. Guthrie (2021) argues that even a perfectly designed study may be of limited value when its results cannot be generalized.

Given the instability of municipal coalition administrations, respondents were often non-committal to the agreed dates, in most of the municipalities on the study sample, there were some delays in obtaining data. The shifting schedules of the respondents occasioned by lack of stability in the municipalities might have compromised the veracity/legitimacy of the responses, as people might have had considerations and misgivings about being truthful.

7.4.3 Lockdown Restrictions

Owing to lockdown restrictions, the researcher was unable to complete interviews due to the COVID-19 epidemic. After the restrictions were eased, the selected informants still preferred online interviews to contact sessions. Connectivity and data issues contributed towards delays in completing data collection.

7.5 STUDY CONSTRAINTS

7.5.1 Budget Restraints

Budget constraints may restrict the number of data collection methods or independent indicators of key variables (Creswell and Poth, 2019). The researcher was mindful that richness of the data collected should not be reduced, due to financial constraints. Data gathering and processing come at a cost, however self-administered questionnaires (rather than surveys), data input via handheld devices, prioritizing informants, and other less expensive data collectors were employed in the

study to help to reduce data collection costs. The research costs were subsidised by the researcher, as there was no financial assistance provided by the institution. Although this was a concern at the start of the exercise, the researcher managed to contain and manage this constraint.

7.5.2 Time Constraints

In real life, researchers are faced with time constraints or have very little time before a deadline to complete some search tasks. The participants were also informed that the purpose of this study was not to test capability skills with and without time constraints, but rather to investigate how the development of capability framework may contribute towards resilient infrastructure management in Category B4 municipalities.

Application of the framework in practice though, was not without time constraints. The researcher did not have endless time to observe and test. What was garnered was what could be possibly achieved in the allotted time.

7.7 RESEARCH IMPLICATIONS AND RECOMMENDATIONS

7.7.1 Summary of Findings

According to OPM3 theory, the greatest technique for improving proposed capability maturity in an organisation is to consistently raise the levels of maturity for employees. The OPM3 has been widely used in the business sector (Brathwaite, 2018; Bento, 2019; Conz and Magnani, 2019; PMI, 2019; Khraiwesh, 2020; SEI, 2021) and has proven to be quite effective in providing an appropriate capability improvement in the areas where it has been used.

In South Africa, the capacity and engineering skillsets to exercise powers and perform service provision functions vary between categories of municipalities (MDB, 2019). The study findings in the case study municipalities confirmed the service provision inadequacies and the continued struggle to attract the necessary mature ES to undertake municipal infrastructure management functions continued. Although the capacity-building support programmes were seen to bridge ES skills gaps in low-capacity communities, findings corroborated with the findings in reviewed literature (Conz and Magnani, 2019; ICMA, 2020; Lephoto and Khatleli, 2020) that, previous ES support programmes were either ineffective or lacked the resilience component.

The study findings further confirmed that the Category B4 municipalities remain unable to survive, adapt, and continue to provide reliable services after ES support is withdrawn. This pointed towards the resilience-gap in capability improvement programmes. Thus, the concept of

resilience was established in this study for a number of reasons, the first of which was to present a viable self- improvement alternative tool to municipalities' continuous reliance on external ES support for infrastructure management (ACSE,2017). The Global CEO (2021) survey resilience criteria was also adopted in this study, due to its distinctive, advanced qualities, such as composite organizational abilities and procedures.

7.7.1.1 Implication of findings for Practice

Since the CMF is centred on an ongoing improvement pathway of critical capacities on many levels with corresponding key process areas at each level, this thesis should be seen as contributing to the improved understanding of how local government actions, processes, and measures can inform unique progression characteristics that are crucial in modelling a continuous improvement pathway towards resilient infrastructure management by Category B4 municipalities. The use of this framework is therefore recommended to support the building of capability maturity through the layered development of infrastructure management knowledge across the category B4 municipalities.

7.7.1.2 Implications for Future Research

The findings of several studies (Bento, 2019; Lawless, 2019; Schriber, 2020; Aghimien et al, 2022) confer this study recommendation that cities are desperate for engineering capacity resilience reclamation efforts. Despite the consistency in the proposed methods for this research and the data collection methods used in previous studies, strikingly, none of the interventions has recommended and developed the capability framework to improve resilience in infrastructure management capabilities for Category B4 municipalities, except the current study. Therefore, future researchers are expected to extend the proposed framework into a model, which will aid in the development of a systematic improvement path for infrastructure management capacities in Category B4 municipalities.

7.7.3 Research Methodology Recommendations

This research has helped us better comprehend the concept of capacity building and upgrading for infrastructure management resilience. Furthermore, the study provides considerable detail on capabilities as well as a systematic pattern of capability advancement, i.e., defined capability maturity levels. However, it is suggested that the methodology include analysing benchmarks and efficiency characteristics of what constitutes a good framework, as testing was outside the scope of this study. The study was however, validated externally through further expert

verification. The expert meeting held on Zoom to verify the framework consisted of a MISA representative and a SAICE retired engineer.

The workshop is a methodical approach consistent with previous studies (as detailed in the literature review section), wherein the expert panel according to Scheepers (2015) was involved in the development and validation of the proposed capability maturity models. Drawn from study and previous studies on infrastructure management and engineering competency areas, an expert review process exercise was performed to confirm the validity of the capability maturity framework in achieving resilient infrastructure management and service provision of the Category B4 municipalities.

This guaranteed that the identified capacity areas could be applied to the Category B4 municipalities' resilient capability maturity framework. The expert review process can be used to achieve a variety of objectives - in this study, it was adopted to confirm the applicability and suitability of the framework capability areas for achieving infrastructure management resilience. Testing the framework in the workplace is still recommended to establish certain standards for when the framework is regarded successful.

7.7.4 Policy Recommendations

The notion of Capability Maturity Models (CMM) was used in this study to modify the existing model. The study contributes the 6th stage of the '*resilience component* 'to the existing 5-staged CMM. Actors were able to interactively construct reality using the observations from the OPM3 model wherein the '*resilience gap'* was imminent. In building a capability maturity framework for infrastructure management capability maturity resilience for Category B4 municipalities, the researcher uses a bottom-up generative approach that focused on gaining information on existing maturity models leading to the modification of the OPM3 maturity model (PMI, 2017).

The objective is that the study will make a difference in policy and will most likely be valuable to policymakers in changing the ways public infrastructure delivery is implemented. This study identified 14 capability areas that can improve local government infrastructure management resilience. The capabilities include various actions, processes, and measures that an organisation can use to improve its infrastructure management resilience. The capability areas include budget alignment and infrastructure delivery cycles, development of construction procurement documentation, cost management, contract management.

Others are the infrastructure liability management, construction quality audits and life cycle asset operation and management of infrastructure, risk management. The systematic approach can be used to benchmark processes for capability enhancement. This might help the local government sector as well as regulatory entities. The depth of the nature of the framework, as well as the engagement of experts and case study municipalities, increased the framework's reliability and suitability for its intended purpose.

7.7.5 Recommendations to Practice

Identification and confirmation of capability improvement areas for infrastructure management resilience in municipalities categorised as B4 is a contribution to practice. The capability maturity framework for infrastructure management in the category B 4 municipalities has emerged as part of this study. There is no other framework that has been presented to date to achieve the goal and functionality of the framework developed in this study. The intention of the framework offered in this study is to act as a self-improvement and an external evaluation tool for creating rural municipalities' infrastructure management resilient capabilities. Therefore, the implication of using the infrastructure management capability framework is that, category B4 municipalities will have a better understanding of their infrastructure management responsibilities and advancement in terms of providing basic services. The framework proposed in this study will be useful to technical managers as a reference for planning and implementing measures to improve resilience of infrastructure management capabilities. It has given a systematic approach to assessing and improving infrastructure management skills. The systematic approach can be utilised to benchmark capability improvement processes to guide future research. The findings of the research should be shared to local government stakeholder forum platforms such as South African Local Government Association (SALGA) and the Provincial Infrastructure Forums that are knowledge sharing platforms normally used to disseminate information to municipalities.

7.8 CONCLUSION

The context of the research problem was briefly described in Chapter One. The second literature review chapter focused on the relationship between service delivery, infrastructure management and the resilient engineering capabilities of South African municipalities. The following study concepts, service provision, engineering skills, capability models and resilience were defined in this chapter. The lack of engineering skills and infrastructure management capabilities and its

effects on service provision, particularly in the context of Category B4 municipalities were covered. The third chapter examined the research methodology and discussed the study's theoretical framework and gives the conceptual foundation for the investigation. The chapter identified an important gap in literature concerning the capability maturity framework for resilient infrastructure management for Category B4 municipalities. The methodology used in the research was presented and supported. The chapter also covered how the case study research design was used during the project's execution in terms of the qualitative approach, data collection methods, research design, and data analysis and verification. The fourth chapter gave a presentation of research findings and looked at four case study municipalities (Mhlontlo, uMzimvubu, Nyandeni, Mnquma located in the Eastern Cape and Moretele in the North West Provinces of South Africa). Presentation of contrasts and similarities discovered during data analysis both within and across the Mnquma, Nyandeni, Moretele, and Mhlontlo Category B4 municipal settings. The chapter also presented Creswell's five stage data analysis procedure, which was useful in allowing distinct gathering, analysis, and interpretation of qualitative data sets from the case studies. The development by expert group and verification of the key capability areas to be included in the capability maturity framework for infrastructure management resilience is presented in chapter six. The framework development was presented in this chapter, as the most significant outcome of this study. The last chapter details how the objectives are met, while detailing study implications and recommendations for future research, recommendations to policy makers and recommendation to academia.

In conclusion the researcher investigated the failure to attract and retain capable technical expertise and experienced engineers, critical for continued service provision, which has been problematic in the rural Category B4 municipalities. The objective of the research study was to examine the capability maturity framework developed for infrastructure management resilience in Category B4 municipalities. By using the PMI Organization Project Management (OPM3) model, to conduct a gap analysis on capability areas. Thereafter, a self-improvement template was developed to contribute to the improved understanding of how local government actions, processes, and measures can inform unique progression characteristics that are crucial in modelling a continuous improvement pathway towards resilient infrastructure management by Category B4 municipalities. The study inquiry was limited to two provinces, the Eastern Cape and North-West Provinces, representative of the precise attributes of the Category B4 municipalities under enquiry. A qualitative case study approach by means of interviews was triangulated with document review, to investigate the study phenomena in the selected case study

municipalities. The study findings in the case study municipalities confirm the service provision inadequacies and the continued struggle to attract the necessary mature ES to undertake municipal infrastructure management functions. Recommendations for future research were made to extend the proposed self-improvement framework into a model.

REFERENCES

Abdul-Majeed et al, 2018. Infrastructure procurement skills gap amongst procurement personnel in Nigeria's public sector. *Journal of Enginneering Design and Technology*, 16(1), pp. 2-24.

ACSE, 2017. *Infrastructure Report Card: A comprehensive Assessment of America's Infrastructure,* s.l.: American Society of Civil engineers.

Aghimien et al, 2021. A confirmatory factor analysis of the challenges of effective management of construction workforce in South Africa. *Journal of Engineering, Design and Technology,* Ahead of print(Ahead of print).

Aguinis, H., Solarino, A. M. T, 2019. Transparency and replicability in qualitative research: The case of interviews with elite informants. *Strategic Management Journal,* 40(8), pp. 1291-1315.

Alliance, R., 2017. *Assessing resilience in social-ecological systems: Workbook for practitioners.* Stockholm, Sweden, August 20-23, 2017, Alliance, Resilience.

Alpi, M. K., 2019. Distinguishing Case Study as a Research Method from Case Report as a Publication Type. *Journal of the Medical Library Association,* 107(1), pp. 1-5.

Andrade, C., 2021. The Inconvenient Truth About Convenience and Purposive Samples.. *Indian Journal of Psychology,* 43(1), p. 86–88.

Andreas, D., 2021. Back to the futures: learning from the evolution of global sustainability governance. INT: s.l.:Public Administration, pp. 140-146.

Anon., 2019. Nation Treasury Standard for Infrastructure procurement and Delivery: Pilot roll out in selected municipalities. *MISA*, pp. 1-88.

Argyris, C., 2017. *Integrating the Individual and the Organization.* 1st edition ed. New York: Routlouge.

Awuzie, B.O & Mc Dermott, P., 2017. An abductive approach to qualitative built environment research: A viable system methodological exposé",. *Qualitative Research Journal,,* 17(4), pp. 356-372.

Bento, I. J. &. R. M., 2019. The Relationship between OPM3 and project management: A multiple cases study.. *Journal of Modern Project Management,* 6(18), pp. 46 - 58.

Bouncken,Y. Qiu and García, F.J.S., 2021. Flexible pattern matching approach: Suggestions for augmenting. *Technological Forecasting & Social Change,* 167(120685), p. 167 (2021) 120685.

Brathwaite, J., 2018. "A contemporary twist on capability enhancement: How strategic project management influences capabilities, requirements and relationship with strategic outcomes". *The Business and Management Review,* 9(4), pp. 574-591.

Brown, C., Seville, E., & Vargo, J., 2017. Measuring the organizational resilience of critical infrastructure providers: A New Zealand case study. *International Journal of Critical Infrastructure,* Volume 18, p. 37–49..

Bryman, A & Bell, E., 2021. *Business Research Methods.* 6th ed. Oxford: Oxford University Press..

Canadian Infrastructure Report, C., 2019. *Monitoring the State of Canada's Core Public Infrastructure,* s.l.: s.n.

Census, 2022. [Online].

Certo, S.C ; Peter, J.P., 1991. *Strategic Management Concepts and Applications.* 2nd ed. New York: Mc Graw – Hill, Inc..

Charmaz, K. &. T. R., 2020. The pursuit of quality in grounded theory. 22 June.pp. 305-327.

Chowdhury and Shil , 2021. Thinking 'Qualitative' Through a Case Study: Homework for a Researcher. *American Journal of Qualitative Research,* 5(2), pp. 190-210.

Coghlan&Mani, 2021. Action research in business and management: A reflective review. *Action Reseaarch,* 19(3), p. 518–541.

COGTA, 2018. *List of Dysfunctional and Distressed Municipalities,* s.l.: COGTA.

Conz and Magnani, 2019. A dynamic Perspective on the Resilience of Firms: A Systematic Literature Review and a Framework for Future Research. *European Management Journal.*

Cooper, D. ; Schindler, P., 2018. *Business Research Methods (13th ed.).* 13th ed. Boston: Mc Graw Hill/ Irwin.

Creswell, J. W. and Poth, C. N., 2019. Qualitative inquiry and research design: Choosing among five approaches. 24(12), pp. 3122-3124.

Creswell, J. a. C. D., 2018. *Research design: qualitative, quantitative, and mixed methods approaches.* 5th ed. Los Angeles: Sage.

Daellenbach, W. J. a. U., 2018. Evaluating Inductive versus Deductive Research in Management Studies: Implications for Authors, Editors, and Reviewers. *Qualitative Research in Organizations and Management An International Journal,* 13(1).

Daniel, M., Molwus, J., Nkup, J. & NG, W., 2020. Addressing socio-technical issues in Built environment research: A Philosophical premise. *Urban Issues,* Volume 65, pp. 45-52.

Davids, D. T. M. M., 2019. Theoretical and Empirical Researches in Urban Management. *: Research Center in Public Administration and Public Services,* 14(2), pp. 20-40.

Denzin, K. & Lincoln, S., 2018. *The SAGE handbook of qualitative research.*. Los Angeles(CA): Sage.

Duchek, S., 2019. Organizational resilience: A capability-based conceptualization. *Business Research,* Volume 13, p. 215–246.

DWS, 2019. *https://www.gov.za/national-water-and-sanitation-masterplan.* [Online] Available at: www.dwa.gov.za [Accessed 03 December 2020].

ECSA, 2021. Annual Report.

Flyvbjerg, B., 2021. Top Ten Behavioral Biases in Project Management: An Overview. *Project Management,* pp. 74-87.

Folke, C., Colding, J., Berkes, F., 2003. Synthesis: Building resilience and adaptive capacity in socio-ecological systems. In Berkses, F., Colding, J. & Folke, C. (Eds.),. *Navigating socio-ecological systems,* pp. 352-387.

Fowler, F. J. and Kettler J, 2022. *The Opportunities and Challenges of Online Data Collection.* Newbery park, CA: SAGE Publications, Ltd..

Ganiyu and Afolabi, 2021. Impact of Cooperative Membership on Rural Income Generation in Southwest,. *Geography Socio- economic,* 138(e75563), pp. 7-14.

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A. and Corley, K. G.,, 2018. Finding theory-method fit: A comparison of three qualitative approaches to theory building. *Journal of Management Inquiry,* 27(3), pp. 284-300.

GGA, 2021. *Dimensions of freedom and governance: past, present, future,* s.l.: GGA.

Ghobadian, A., O'Regan, N., Gallear., D. Bitar, J. & Hafsi, T., 2007. Strategizing through the capability lens: Sources and outcomes of integration,. *Journal of Management Decision.*

Ghosh, M., 2017. Infrastructure and Development in Rural India. *The Journal of Applied Economic Research · ,* August.

Gilgun, F., 2019. Deductive Qualitative Analysis and Grounded Theory: Sensitizing concepts and Hypothesis- Testing. *SAGE Handbook of Current Developments in Grounded Theory*, pp. 107-122.

Glas, A.H., Schaupp, M, Essig, M, 2017. An Organizational Perspective on the Implementation of Strategic Goals in Public Procurement. *Journal of Public Procurement,* 17(4), pp. 572-605.

GroupAreasAct, 1950. *Act 41,* s.l.: s.n.

Guthrie, J. J. D. C. N. M. L. M. M., 2021. *Research Handbook on Intellectual Capital and Business.* Los Angles: Sage.

Handbook, L. G., 2019. A complete guide to municipalities in South Africa.

Hassan, A.S. & Faris, A.A., 2019. Influences of Project Management Capabilities on the Organizational Performance of the Saudi Construction Industry;. *Journal of Engineering, Technology & Applied Science Research,* 9(3), pp. 4144-4147.

He, Z., Huang, H., Choi, H., Bilgihan, A., 2021. Building Organizational Resilience with Digital Transformation. *Journal of Service Management,* pp. 1757-5818.

Hendriks, F, Kienhues, D., Bromme, R., 2020. Replication crisis = trust crisis? The effect of successful vs failed replications on laypeople's trust in researchers and research. *https://doi.org/10.1177/0963662520902383,* 8 February.

Hillmann, J. and Guenther, E.,, 2021. Organizational resilience: A valuable construct for management research?. *International Journal of Management Reviews,* 23(1), pp. 7-44.

Holling, C., 2017. Bubbles and Spirals: The Memoirs of Buzz Holling. *Annual review of Ecology and Systematics,* Issue 4, pp. 1-24.

ICMA, 2020. *Technical Assistance for Small Towns and Rural Communities,* s.l.: International City Manager's Association.

IDMS, 2019. *Nation Treasury Standard for Infrastructure procurement and Delivery: Pilot roll out in selected municipalities,* s.l.: Municipal Infrastructure Support Agency (MISA).

IDP, M., 2019. *Moretele Local Muncipality.* [Online] [Accessed 2023].

IIPSA, 2021. *Infrastructure Investment Programme for South Africa (IIPSA).* Johannesburg, DBSA.

ISO9004, 2018. *Quality management systems - Guidelines for performance improvements.* s.l.:s.n.

Johnson, Russo and Schoonenboom , 2017. Causation in mixed methods research: The meeting of philosophy, science, and practice. *Journal of Mixed Methods Research,* Volume 11, pp. 156-173.

Joseph, J., 2013. Resilience as embedded neoliberalism: A governmentality Approach,. *Resilience: International Policies, Practices and Discources ,* 1(1), pp. 38-52.

Kampira, A., 2021. Brief Introduction to Thematic Analysis. *Afregarde Research.*

Kanyane, M., 2011. Financial Viability of rural municipalities in South Africa.. *Journal of Public Administration ,* 46(2), pp. 935-946.

Kaushik, V. a. W. C., 2019. Pragmatism as a Research Paradigm and Its Implications for Social Work Research. *Soc. Sci,* 6 September , Issue 8, p. 255.

Kerzner, H., 2019. . *Using the project management maturity model: strategic planning for project management.* s.l.:John Wiley & Sons.

Khraiwesh, M., 2020. Measures of organizational training in the capability maturity model integration (CMMI). *International Journal of Advanced Computer Science and Applications,* 11(2), pp. 584-592.

Klaas, M. a., 2020. The Divergence of Small Towns Talk and Action in Water Services in Uganda. *Water Alternatives,* 20(13).

Kostalova, J. and McGRATH, J.,, 2021. Sustainability in Project Management: Two sides of the same coin or poles apart?.. *HDE.*

Lawless, A., 2007. *Needs and numbers.* First ed. Johannesburg: SAICE.

Lawless, A., 2015. Numbers and Needs in Local Government . INT: *Addressing Civil Engineering - The Critical Profession for Service Delivery.* Midrand: SAICE, pp. 1-12.

Lawless, A., 2019. *UNESCO 6TH Africa Engineering Week and 4th Africa Engineering Conference: "Addressing the SDGs through Sustainable.* Livingstone, Zambia, SAICE.

Lephotho and Khatleli, 2020. Efficacy of expat professionals engineering skills in SA mega construction projects. *Research Gate.*

LGSETA, 2018. Local Government Organising Framework for Occupations (OFO) Code Handbook..

Linnenluecke, M. K., Marrone, M., and Singh, A. K., 2020. Conducting Systematic Literature Reviews and Bibliometric Analyses,. *Australian Journal of Management,* 45(2), pp. 175-194.

Linnenluecke, M. K., 2017. Resilience in business and management research: A review of influential publications and a research agenda. *International Journal of Management Reviews,* Volume 19, p. 4–30.

Malalgoda, D.A., Haigh, R., 2011. *Empowering local governments to make disaster resilient cities. International Interdisciplinary approaches to disaster risk reduction and development of sustainable infrastructure.* Conference on Building Resilience, s.n.

Manu, P., Mahamadu, A.M., Booth, C., Olomolaiye, P.O., Coker, A., Ibrahim, A. and Lamond, J., 2019. "Infrastructure procurement capacity gaps in Nigeria public sector institutions". *Engineering, Construction and Architectural Management,* 26(9).

Marks, S. J., Marks, G., Clair-Caliot, L.T., James T. B, C.K, Namanya, E.R., Jeltsje S.S., Frank K., Dauda W. B., & Giuliana, F., 2020. Water supply and sanitation services in small towns in rural–urban transition zones. *Clean Water.*

Markus, M.L, Majchrzak, and Rowe, F., 2021. Theoretical Diversity in IS Research: A Causal Structure Framework. In Advancing Information Systems Theories. *MIS Quarterly,* 26(3), pp. 75-130.

Mathonsi & Sithole, 2015. Local Governance Service Delivery Issues During Apartheid and Post-Apartheid South Africa. *Africa's Public Service Delivery & Performance Review,* pp. 1-26.

Mauthner, 2020. Research Philosophies an Why they matter.

MDA, 1998. *Republic of South Africa (1998). Municipal Dermacation Act No. 27 of 1998;*, Pretoria: Government Gazette, Republic of South Africa.

MDB, 2018. *Municipal Demarcation Board, Municipal powers and functions Capacity Assessments,* Pretoria: Municipal Demarcation Board.

MDB, 2019. *Municipal powers and functions Capacity Assessments,* Pretoria: Municipal Demarcation Board.

Mensah, J., 2019. Managing environmental sanitation in the catchment area of Benya: Infrastructure management as a matter of strategic priority. *Cogent Social Sciences,* pp. 1-16.

Messick, S., 1989. Validity. In Linn, R.L. (ed.). Educational measurement.. *American Council on Education/Collier Macmillan,* pp. 13-103.

MIIF, 2021. *Municipal Infrastructure Investment Framework for South Africa A Capital Investment Perspective (MIIF 7),* Midrand: Development Bank of South Africa.

Mirti, A., 2018. Place Based Approach to Plan for Resilient Cities: A local government perspective. *Procedia Engineering.,* 21(2), pp. 157-164.

Morgan, A., Naylor, G., and Raiden, A.,, 2008. *Does construction Skills policy reflect local needs for skills investment?.* s.l., s.n.

MSA, 2000. *Republic of South Africa, Municipal Systems Act (32).* [Online].

MSA, R. o. S. A., 1998. *Republic of South Africa, Municipal Structures Act (MSA) No.117 of 1998;,* Pretoria: Government Printers .

Ngomane, L., 2018. *The Role of Self Governance in Mitigating the Effects of Mine-water Management, The Case of Emalahleni, Mpumalanga, South Africa,* s.l.: s.n.

Njikelana, V., 2016. *A critical assessment of Eastern Cape Provincial Government Intervention in Dysfunctional municipalities (Dissertation), Masters, University of Fort Hare.* s.l.:s.n.

Ntliziywana, P., 2017. *Transformation of local government in South Africa, Failures and Limits of Legislation (Dissertation), LLM, University of Western Cape.* s.l.:s.n.

Pal, R., Westerlind, R., & Torstensson, H., 2013. Exploring the resilience development process by implementing the crisis strategic planning framework: A Swedish textile SME perspective.. *International Journal of Decision Sciences, Risk and Management,* 5(1), p. 134.

Palmatier, R. W., Houston, M. B., & Hulland, J. , 2018. Review articles: Purpose, process, and structure. *Journal of the Academy of Marketing Science,* 1(5), p. 46.

Palmer, I., Moodley, N., Parnell, S., 2017. *Building a Capable State: Service Delivery in Post-Apartheid South Africa.* United Kingdom: Bloomsbury .

Park, J. E., 2021. Curbing cost overruns in infrastructure investment: Has reference class forecasting delivered its promised success? .. *European Journal of Transport and Infrastructure Research,* 21(2), p. 120–136.

Patrucco, A.S, Antonrlla, A, Ronchib, M.S., 2019. Orgnisational choices in public procurement: What can public management learn from the private sector?. *Local Government Studies,* 45(6), pp. 977-1000.

Peels & Bouter, 2021. Replication and trustworthiness, Accountability in research,. *Online Journal Taylor & Francis.*

PMI, 2017. *Organizational Project Management Maturity Model: OPME knowledge foundation,,* Newtown Square, Pennsylvania: s.n.

PMI, 2021. *Project Management Institute, A Guide of Project Management Body of Knowledge (PMBOK),* Newtown Square, Pennsylvania: Project Management Institute, Inc.

Prater, J., Kirytopoulos, K., Ma, T. , 2019. Exploring the factors impacting upon the accuracy of project managers' baseline schedules. *Journal of Construction Engineering and Management Dilbert moments.*

Rebuild, R., 2017. *Infrastructure Priorities for Rural Prosperity in America,* Washington DC: s.n.

Renz, Susan M.; Carrington, Jane M. & Badger, Terry A. , 2018. Two strategies for qualitativecontent analysis: An intramethod approach to triangulation. *Qualitative Health Research,* 28(5), pp. 824-831.

RICS, 2017. *Infrastructure Management: Current Practices and future trends* , London: RICS - Royal Instituion of chartered Surveyors .

Roberts, P.W., & Dowling, G.R., 2002. Corporate reputation and sustained superior financial performance. *Strategic Management Journal,* 23(12), pp. 1077 -1093.

Rockefeller, F., 2019. *Resilient Cities, Resilient Lives learning from the 100RC Network* , s.l.: .

Rodrigo, and Perera, 2017. Advances in Construction ICT and e-Business. INT: *Advances in Construction ICT and e-Business.* s.l.:Routlege, p. 33.

RSA, 1996. *The Constitution, Act No. 108 of 1996. Government gazette of South Africa, 31792, 18 December 1996.*, Pretoria: Government Gazette.

RSA, 1998. *White Paper on Local Government.* [Online].

RSA, 2000. *South African Government, Municipal System Act.* [Online] Available at: www.gov.za [Accessed 7th April 2022].

RSN, 2021. *Rural Services Network: Revatilising Rural*, s.l.: s.n.

SACN, 2019. *South African Conversations on InfrastructuRES: A Compendium of the Infrastructure Dialogues,* s.l.: South African Cities Network (SACN).

SACN, 2021. *State of the City's Report,* s.l.: s.n.

SAHO, 2022. South African History online 2022.

SAICE, 2020. *SAICE Infrastructure Report Card,* Midrand, Johannesburg: SAICE.

Sandford, M., 2022. *Devolution to local government in England.* London, House of Commons Library.

Sansom, K. H. D. a. K. S., 2018. International water targets and national realities in Sub-Saharan Africa. *Contemporary Social Science,* 13(1), p. 17–29.

Saunders, M.N.K., Lewis, P.Thornhill, A., 2019. *Research Methods for Business Students.* 8th ed. Harlow, UK: Pearson.

Saunila, M., 2016. Performance measurement approach for innovation capability in SMEs.. *International Journal of Productivity and Performance Management,* 65(2), pp. 162-176.

Scheepers, L., 2015. *Institutional Capacity Model for municipalities in South Africa, (Dissertation) PhD,*. Cape Town : Stellenbosch University.

Schriber, B. a. L. J., 2020. Reconsidering ordinary and dynamic capabilities in strategic change. *European Management Journal,* 38(3), pp. 377-387.

Schwandt, T., 2017. Three epistemological stances for qualitative inquiry: Interpretativism, hermeneutics and social constructionism.. INT: *The Landscape of Qualitative Research: Theories and issues.* s.l.:s.n., pp. 292-331.

SEI, 2021. *An Integrated Safety, Health and Environmental Management Capability Maturity Model for Construction Organisations: A Case for Ghana,* s.l.: Software Engineering Institute.

Shamout,Boarin, Mannakkara, 2020. *Understanding resilience in the built environment. The 54th International Conference of the Architectural Science Association (ANZASSCA).* s.l., s.n., pp. 253-270.

Snyders, H., 2019. Literature review as a research methodology: An overview and guidelines. *Journal of Business Research,* pp. 1-8.

Sprogis, K., Currey, J., Jones, D., Considine, J, 2021. Understanding the pre-medical emergency team tier of a mature rapid. *Australian Critical Care,* 34(2021), pp. 427-434.

StatsSA, 2022. *Statistics South Africa, Community Survey,,* Pretoria: Government Gazette, Republic of South Africa.

Strauss, A., 1987. Qualitative Analysis Social Scientists.

Taute, N., 2021. The use of collaborative partnerships to improve service delivery in South African local government. *Journal of Contemporary Management,* 17(2).

Teddlie, C., Tashakkori, 2009. *Foundations of Mixed Methods research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioural Sciences.*. Thousand Oaks, CA: Sage.

Teece, D. J., 2018. Business models and dynamic capabilities. *Academy of Management Perspectives,,* 28(4), p. 328–52.

Thelwall, M. & Nelville, T., 2021. Is research with qualitative data more prevalent and impactful now? Interviews, case studies, focus groups and ethnographies. *Journal of the American Society of Information Science and Technology,,* 43(2).

Tomas, H., 2022. A Seat at the Table: Municipalities and Intergovernmental Relations in Canada. *Institute on Municipal Finance and Governance,* Issue 10.

Treasury, N., 2020. *Local Government Budget and Expenditure Review: 2013/14 – 2017/18, Chapter 12: Delivering Municipal Services in Rural Areas.,* Pretoria: Government printers, Republic of South Africa.

TRI, T. R. I., 2017. *Review of Contemporary Research in the Field of Community-Based Disaster Resilience.* [Online]

Available at: https://frrr.org.au/wp-content/uploads/2020/11/Formatted-DR-FR-Lit-Review2017_Final.pdf
[Accessed 2021].

Tshishonga, N., 2019. Prospects and Challenges of Transforming Local Government into a Learning Organisation. *African Journal of Public Affairs*, 11(1).

UNICEF, W. &., 2017. *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines.*, GENEVA: World Health Organization.

UN-Water, W. &., 2017. *Financing universal water, sanitation and hygiene under the sustainable,* GENEVA: WHO.

Urban, J.B., and van Eeden-Moorefield, B.M., 2018. Choosing whether to use a qualitative, quantitative, or mixed-methods approach.. INT: *Designing and proposing your research project.* s.l.:s.n., pp. 25-34.

Van den Berg, C., & Danilenko, A, 2017. *Performance of water utilities in Africa.*, Washington, DC: World Bank.

Van der Walt, G., 2020. *Constructing conceptual frameworks in social science research.* s.l., Sabinet.

Vivek, S. A., 2021. Resilience and OCB among Employees of Information Technology Sector in Kerala: An Empirical Study. *Institute of Management and Technology*, 14(2), pp. 20-26.

Wall, K., 2021. The right to functioning urban infrastructure – A review. *African Journals Online,* Issue 79.

Warner, M., and Kim, Y, 2021. Pragmatic Municipalism: Local Government Service Delivery After the Great: US local government responses to fiscal stress. *Public Administration Review,* 81(3), pp. 389-398.

WEO, 2019. *Africa Energy Outlook,* s.l.: s.n.

Wilson, J., 2021. *Understanding Research for Business Students: A Complete Student' s Guide.* s.l.:SAGE.

Winch and Sergeeva , 2022. Temporal structuring in project organizing: A narrative perspective. *International Journal of Project Management*, 40(1), pp. 40-51.

Yin, R., 2018. *Case study research and applications: Design and methods.*. 6th ed. Thousand Oaks: CA:Sage.

Zaidan and Younus, 2022. The influence of quantitative research in business & information technology: An appropriate research methodology research methodology philosophical reflection. *American Journal of Interdisciplinary Research and Development.*

APPENDIX A - TRANSCRIBED INTERVIEWS

File : Research Interview TD -Mhl

Duration : 0:59:04

Date : 23-04-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for taking time to talk to me today. I did receive the signed consent form, thank you.
0:00:02	**RES:** You most welcome!
0:00:03	**INT:** You mentioned that you have been working in the built environment for the past 5 years, was it in this municipality, in particular?
0:00:04	**RES:** Yhea, that's correct, I joined this municipality in March 2018,
0:00:05	**INT:** Can you talk me through your day-to-day role as a technical director in a rural municipal set-up!
0:00:07	**RES:** Essentially my day-to-day responsibilities include the development and monitoring of capital projects implemented by various divisions water & sanitation, roads and solid waste. Manage Municipal Infrastructure Grant (MIG) funded Programmes. Oversee adherence to labour-intensive projects in accordance with the Expanded Public Works Programme (EPWP) framework and reporting criteria. Ensure that the municipality's IDP objectives are achieved, budget spent, and SDBIP targets realised.
0:00:08	**INT:** **What is your highest engineering qualification?**
0:00:09	**RES:**

	B Tech
0:00:10	**INT:** **Are you registered with CESA?**
0:00:11	**RES:** Not yet, still a candidate. Should I say, "I am an ***unregistered Civil Engineering Technologist***." I have been meaning to register but, I hardly have the time to put together the report. With the help of a mentor, I believe one can speed up the report and submit.
0:00:12	**INT:** **What has your municipality's experience been as a recipient of the Municipal Infrastructure Support Agency (MISA) engineering support program?**
	RES: - Well, the MISA deployee that was sent to support the municipality and transfer the skills to our technical services department, just does his work. He comes to me only to brainstorm and discuss what needs to be done, but never have a plan to walk – hand-in-hand with the incumbent technical staff so as to transfer skills - A structured support plan of some sort is required when support is being provided
	INT: **How would you describe your municipality's success in infrastructure planning and acquisition life-cycle management, as well as contract management, during the course of the support period?**
	RES: **Up ……phew**, contract management was extremely difficult for us before we received the SAICE Siyenza Manje engineering support programme. In terms of acquisition life-cycle management, the support engineers' expert knowledge of supply chain issues protected us from the municipality's deficient supply chain management systems, which at first impede infrastructure procurement and service delivery, making it difficult to achieve value for money and resilient high-quality infrastructure projects. Well, with regards to contract management, we've had concerns with contractors that get awarded capital projects because they have a higher CIDB grade 5, only find out when they come on site that they are unable to carry out the task at hand. Contractors who carried out work on our behalf and appeared to be more knowledgeable than our personnel were no match for the support engineers who breathe and lived GCC. **Mhmm what a pleasure -** The support engineers just did the work. We were supported in putting together contracts that include contract data, schedule of deviations, pricing information, and the scope of work. **Yhoo, what I realised**, we just could not adapt when our assistance is withdrawn as there were no templates to refer back on
	INT:

	What are the fundamental project management practices your municipality presently utilize in scope management, cost management controls, contract management, and project quality monitoring?
	RES: In actual fact, project management templates will aid in increasing the success rates of our engineering projects. ***Scope management***– the project leader's level of experience, coupled with a well-written civil engineering proposal is the starting point. Our expertise in translating project design to specification that must go into a tender proposal is a huge challenge. ***Cost management controls***– ideally it is our responsibility to minimise cost where possible; revealing areas of cost overspend. ***(Taking a deep breath)*** I must say this is one area we are falling short, again a template on how to accomplish this will come in handy. ***Contract management*** – mostly we use General Conditions of Contract (GCC) for managing our capital projects during construction. Yet, I am certain, we do not have appreciation of the fundamental terms and clauses of a contract and how to remedy a breach of contract when it eventually happens in our projects. ***In fact, if I may say this, though it is embarrassing***, ***but it's a fact***, "contractors and consultants implementing our projects are more well-informed with the GCC prescripts and clauses more than our project managers do, for the very reason that they always want to take advantage whilst making more money. This is more prevalent on claims for P&G's, extension of time claims, ***Project quality monitoring***– In managing the infrastructure projects, as technical employees, monitoring construction projects, we must be able to make decisive choices, such as initiating necessary remedial measures and/or terminating the project if it becomes unviable or if there is poor quality workmanship. Stopping defective workmanship should be the norm, not an eventuality as we do currently.
	INT: **That's really a mouthful hey. Can I move to the next question?** **W**hat are the critical areas for rural Category B4 to nurture resilient infrastructure management capacities in these municipalities?
	RES: ***Yea,*** Life-cycle management taking into consideration preventative and routine maintenance
	INT: What design elements would help in the development of a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES: What comes to mind first is quality monitoring and contract management capabilities Also, I guess we must find expression of regulating contractors working on infrastructure projects

0:59:02	**INT:** Thank you kindly for your valuable time
0:59:04	**RES:** You most welcome, and, I concur with this proposed framework and I want to believe that continuous development of infrastructure management performance is vital for our municipality as we are still dealing with service provision backlogs. We so looking forward to the completion of the framework**.**

File : Research On-line Interview TD -Mnq

Duration : 1:08

Date : 12-04-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for consenting to be interviewed. Please allow me to take you through the questions with as little delay as possible.
0:00:03	**RES:** It's only a pleasure!
0:00:05	**INT:** How long have you been working for Mnquma municipality?
0:00:06	**RES:** In August, it would be 6 years to be exact
0:00:07	**INT:** **What is your highest engineering qualification?**
0:00:08	**RES:** National Diploma in Engineering
0:00:09	**INT:** **Are you registered with CESA?**
0:00:10	**RES:** It's a process that needs time to draft the report.
0:00:11	**INT:** Can you talk me through your day-to-day role as a technical director in a rural municipal set-up
	RES:

	Responsible for the technical services department, which includes water, waste water, project management, electrical, road, and storm water. My responsibilities also include ensuring that all Municipal Infrastructure Grant-identified projects are efficiently and successfully implemented, as well as the existence and implementation of operations and maintenance programmes for existing municipal infrastructure.
	INT: **What has your municipality's experience been as a recipient of the Municipal Infrastructure Support Agency (MISA) engineering support program?**
	RES: In 2018, we were one of the municipalities chosen by MISA to conduct infrastructure assessment and analysis. This was beneficial to this department because we lacked the ability to conduct condition evaluations without knowing how many years our assets had left in service. In other words, we were unable to plan for preventative maintenance.
	INT: **How would you describe your municipality's success in infrastructure planning and acquisition life-cycle management, as well as contract management, during the course of the support period?**
	RES: The MISA initiative intent was to increase the capabilities of our technical department in order to enable better municipal infrastructure life-cycle planning, operations, and maintenance. The emphasis was on knowledge and the competence to improve municipal infrastructure management; however, I am confident that we would have benefited more had the support been extended; two years is far too short to grasp all of the issues.
	INT: **You mentioned earlier that there is quite a lot you learnt from the support engineer deployed in the municipality. What are the fundamental project management practices your municipality presently utilize in scope management, cost management controls, contract management, and project quality monitoring?**
	RES: ***Yes, off course there are lessons learnt but there are some realities we facing in our communities we serving: Scope management*** – Mhhh……the difficulty we face is that community involvement during construction causes scope creep. It is not rare for the contractor to receive demands from the community; therefore, the contractor ends up doing what the community wants rather than what is on the scope. The lesson is to call community meetings during the design/concept development process rather than only communicating with councillors who agree on projects on behalf of communities. ***Cost management controls***– Change is inescapable. There are multiple compelling reasons why scope must alter during a project, also but there will be many requests for which the correct answer is 'no.' During construction, we were a victim of scope variations that led to delays and cost overruns. ***Contract management*** – The difficulty we are facing is asymmetry of knowledge between our project managers and the contractors we engage for our projects. As a result, our project

	control focus is on completing the original project design plans and identifying deviations from these plans. **We received a lot of support from…uh from the deployed engineer, my only wish is documentation, as they technical director I took from didn't handover any templates - [phone ringing].**
	INT: Do you want to take a quick break?
	RES: ***Not thank you, I will call back the Councillor……I was still saying ….mh*** ***Project quality monitoring***– Recognise that quality management during construction means ensuring that projects are of high quality and defect-free. Because we lack the expertise to do quality control, we rely on consultants.
	INT: What are the critical areas for rural Category B4 to nurture resilient infrastructure management capacities in these municipalities?
1:08:00	**RES:** When it comes to cultivating resilient service delivery, there are several services that are frequently scrutinised by the public and the media, such as water and sanitation, power, and roads. These service areas are critical for our municipality to accomplish its constitutional goals of providing sustainable services and encouraging local economic growth.
	INT: Almost done, this is the second last question. What design elements would help in the development of a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES: Self-quality management, cost control measurement, life-cycle planning
	INT: Thank you kindly for your valuable time
	RES: Ndiyabonga (I thank you)

File : Research Interview TD -Mor

Duration : 0:59:18

Date : 23-03-2022

Acronyms : Interviewer (IN); Respondent (RE)

0:00:00	**INT:** Thank you for agreeing to an interview. Please allow me to go over the questions
0:00:02	**RES:** You can go ahead!
0:00:03	**INT:** You've been in the service of Moretele municipality for how many years now?
0:00:06	**RES:** This is my 7th year, I started as an intern I the water & sanitation division, and I was there for 4-years
0:00:07	**INT:** **What is your highest engineering qualification?**
0:00:08	**RES:** National Diploma in Civil Engineering
0:00:09	**INT:** **Are you registered with CESA?**
0:00:10	**RES:** No, when I applied for the position, registration with a recognised relevant engineering professional body was said to be an added advantage not a requirement.
0:00:11	**INT:** Can you outline your day-to-day duties as a technical director?
	RES:

	Lead and direct the Infrastructure and Technical Services department to ensure that services are provided to all areas and communities within the municipal authority. My responsibilities include developing and implementing appropriate strategies, plans, and policies for water and sanitation, roads and storm water, and energy implementation MIG funds via the project management unit.
	INT: **You stated you once had SAICE engineer deployed to support the technical services directorate. What has your municipality's experience been as a recipient of the SAICE professional development program?**
	RES: Yhoo, if you are not careful, you would relax and just leave the deployed engineer to do everything, but when they leave you don't have any reference template to use. Need some balancing act.
	INT: **How would you describe your municipality's success in infrastructure planning and acquisition life-cycle management, as well as contract management, during the course of the support period?**
	RES: ***'Well, it's, erm'*** (**Sounds of uncertainty**), regarding planning decisions as stated previously, there is no reference or rather templates from previous support engineers. You just glad work is continuing.
	INT: **What are the fundamental project management practices your municipality presently utilize in scope management, cost management controls, contract management, and project quality monitoring?**
	RES: ***I believe that if we can get templates on these areas, half of our infrastructure management challenges would have been solved:*** ***Scope management*** – Scope creep during construction, caused by design revisions are some of the realities we face in the rural areas ***Cost management controls*** – Project cost overruns are prevalent, whether they are due to flaws in the project budget or scope, or to technical reasons such as erroneous project estimation.
	INT: What are the critical areas for rural Category B4 to nurture resilient infrastructure management capacities in these municipalities?
	RES: Asset management is key, preventative and routine maintenance
	INT: What design elements would help in the development of a capability maturity framework for infrastructure management resilience in Category B4 municipalities?

	RES: Self-quality management, cost control measurement, life-cycle planning
	INT: Thank you kindly for your valuable time
0:59:18	**RES:** You are extremely welcome,

File : Research Interview TD -Nya

Duration : 0:58:57

Date : 23-03-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for agreeing to participate on this interview.
0:00:02	**RES:** Its' only a pleasure
0:00:03	**INT:** How long have you been working for Nyandeni Municipality?
0:00:04	**RES:** Since 2015
0:00:05	**INT:** **What is your highest engineering qualification?**
0:00:06	**RES:** National Diploma in Civil Engineering
0:00:07	**INT:** **Are you registered with CESA?**
0:00:08	**RES:** No, when I applied for the position, on the advert stated registration with a recognised relevant engineering professional organisation was indicated to be an advantage rather than a requirement.
0:00:12	**INT:** What are your day-to-day tasks as a technical director?

	RES: Directing the Infrastructure and Technical Services department to ensuring the planning and implementation of water and sanitation, roads and storm water capital projects.
	INT: **You stated you once had MISA engineer deployed to support the technical services directorate. What has your municipality's experience been as a recipient of the MISA professional development program?**
	RES: Quality control on our projects has been an issue. MISA deployee provided us with quality control plans. Our technical services department requires the essential capabilities to plan, procure, manage and sign off on projects, as well as to run and maintain the assets after infrastructure is done.
	INT: **How would you describe your municipality's success in infrastructure planning and acquisition life-cycle management, as well as contract management, during the course of the support period?**
	RES: There is just one thing that the senior engineer deployed to this municipality did was to plan for infrastructure, dealing with EAI's, WULA's all the environmental authorisations were just from his fingertips.
	INT: **What are the fundamental project management practices your municipality presently utilize in scope management, cost management controls, contract management, and project quality monitoring?**
	RES: Mmh…… this is the engine of our technical services directorate ***Re -Scope management*** – I appreciate that the most common causes of project failure are a lack of scope management. If the terrible "scope creep" problem is allowed to aggravate and develop, all of the other amazing project accomplishments will be thrown out the window. This municipality has had numerous of our projects fail despite having the necessary experience, timeline, high-quality deliverables, and even delighted clients. ***In relation to cost management controls***– ***(Scratching his head)*** I must emphasise that mismanaging project expenditures is the single most common cause of our project failures. The project costs represent the various multifaceted experiences that occur on a project. ***Contract management*** – I don't want to seem like I'm repeating myself, but we recognise that contract life-cycle management is vital for our construction project managers to monitor any potential changes or violations of contract as infrastructure projects progresses through implementation stages
	INT: You have mentioned previously that there are areas that you need project management templates. What design elements would help in the development of a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES:

	Self-quality management, cost control measurement, life-cycle planning
	INTERVIEWER Thank you kindly for your time, we have come to an end of our interview.
0:58:57	**RES:** Kubulela mna (***Thanks to you***) This interview was an eye opener on issues we should be looking at as the technical service department.

File : Research Interview SAICE retired engineer

Duration : 0:56:17

Date : 23-08-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for accepting being a participant in an interview.
0:00:02	**RES:** Pleasure!
0:00:02	**INT:** Would you kindly tell me your age bracket? 50-60 60-70
0:00:03	**RES:** 51-60
0:00:04	**INT:** **How long have you worked in the built environment?**
0:00:04	**RES:** **22**
0:00:05	**What is your highest engineering qualification?**
0:00:05	**RES:** Msc Civil Engineering
0:00:06	**INT:**

	How has your experience been in providing engineering support to the technical employees in the Category B4 municipality?
	RES: The chronic shortages of municipal engineers have been especially acute in small rural communities, which is why perhaps we were brought in to fill the skills gap. The technical director so to speak, has taken the place of the municipal engineer. However, because professional registration is no longer required for these roles, the burden on service provision or lack thereof has been reduced to the detriment of the public. Municipalities are not safeguarding themselves by employing unsuitable people in technical positions, putting them at risk of irresponsible acts or omissions. What towns fail to recognise is the ethical dimension that comes from registration with the Engineering Council of South Africa (ECSA), which compels registered professionals to carry out their work with honesty and in accordance with recognised professional conduct norms.
	INT: What were the fundamental project management practices you employed in scope management, cost management controls, contracts management and monitoring quality on projects, during your deployment in the Category B4 municipality?
	RES: I approached cost management as a continuous, dynamic process that recognised all four parts, planning, cost estimating, cost budgeting, and cost control. When using project management tools for quality monitoring, the goal is always to complete projects on time and on budget.
	INT: What appropriate strategies were you using to identify suitable engineering designs as part of planning & acquisition life-cycle management practice when initiating rural infrastructure projects?
	RES: As the project progressed from planning to design, one had to review infrastructure designs for constructability. For example, whether the sequence of putting a building structure and the critical loadings on the partially assembled structure during construction are carefully considered as part of the overall structural design. Thus, taking on the burden of addressing the risk-reward conundrum.
	INT: After the cessation of your support contract to rural Category B4 municipalities, what has been your observation regarding the municipalities' ability to sustain service provision continuity, particularly in the areas that you have provided support?
	RES: Due to a shortage of infrastructure projects at the time I was with the municipality, there were not enough learning opportunities. For optimal capacity to offer services efficiently to communities, technical support should be constant rather than for a brief two-year period.
	INT: What key success elements of your support can you identify that are associated with building resilient infrastructure management capabilities in rural Category B4 municipalities?
	RES:

	Capable of managing technical reports, analysing consultant infrastructure designs, and ensuring adequate project prioritising, implementation, and monitoring.
	INT: What are pertinent design elements that would contribute towards developing a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
0:56:17	**RES:** Establish explicit tender methodologies and processes, as well as central standardisation, to ensure quality and value for money.

File : Research Interview MISA engineer NW -1

Duration : 0:58:00

Date : 13-09-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for agreeing to an interview. Please allow me to go over the questions
0:00:01	**RES:** You can go ahead!
0:00:02	**INT:** Would you kindly tell me your age bracket? 50-60 60-70
0:00:03	**RES:** 51-60
0:00:04	**INT:** **How long have you worked in the built environment?**
0:00:04	**RES:** **15**
0:00:05	**What is your highest engineering qualification?**
0:00:05	**RES:** B Hons Civil Engineering

0:00:06	**INT:** How has your experience been in providing engineering support to the technical employees in the Category B4 municipality?
	RES: We were able to reduce infrastructure delivery time to a considerably shorter period
	INT: What were the fundamental project management practices you employed in scope management, cost management controls, contracts management and monitoring quality on projects, during your deployment in the Category B4 municipality?
	RES: Quality control's purpose was to increase quality performance and outcomes. This was accomplished through the identification and prioritisation of improvement opportunities and evaluation of improvement outcomes.
	INT: What appropriate strategies were you using to identify suitable engineering designs as part of planning & acquisition life-cycle management practice when initiating rural infrastructure projects?
	RES: I had to do early-stage screening, feasibility assessments, and thorough implementation review, which included design reviews, financial viability, and cost-benefit analysis to ensure the effective delivery of infrastructure projects,
	INT: After the cessation of your support contract to rural Category B4 municipalities, what has been your observation regarding the municipalities' ability to sustain service provision continuity, particularly in the areas that you have provided support?
	RES: My impression is that municipalities were not adequately prepared to respond effectively to, and recover when support was withdrawn, causing service delivery to be disrupted.
	INT: What key success elements of your support can you identify that are associated with building resilient infrastructure management capabilities in rural Category B4 municipalities?
	RES: Infrastructure master planning is critical as a guideline for mainstreaming resilient life-cycle planning. Accountability amongst technical officials.
0:58:00	**INT:** What are pertinent design elements that would contribute towards developing a capability maturity framework for infrastructure management resilience in Category B4 municipalities?

	RES: Asset management and operation & maintenance stands-out for me

File : Research Interview MISA engineer NW-2

Duration : 0:54:18

Date : 13-09-2022

0:00:00	**INT:** Thanks for allowing me to go over the questions.
0:00:01	**RES:** You may proceed!
0:00:02	**INT:** Would you kindly tell me your age bracket? 50-60 60-70
0:00:03	**RES:** 51-60
0:00:03	**INT:** **How long have you worked in the built environment?**
0:00:04	**RES:** **15**
0:00:04	**What is your highest engineering qualification?**
0:00:05	**RES:** B Hons Civil Eng

0:00:06	**INT:** How has your experience been in providing engineering support to the technical employees in the Category B4 municipality?
	RES: To start with it was critical to diagnose and troubleshoot technical issues that the municipality grapples with, to help solve the infrastructure management problems at hand.
	INT: What were the fundamental project management practices you employed in scope management, cost management controls, contracts management and monitoring quality on projects, during your deployment in the Category B4 municipality?
	RES: I believed in a consistent approach leads in a shortened project life cycle.
	INT: What appropriate strategies were you using to identify suitable engineering designs as part of planning & acquisition life-cycle management practice when initiating rural infrastructure projects?
	RES: When I first joined the municipality, I noticed that the issues the municipality was encountering were the result of inadequate technology that had been deployed owing to faulty design assumptions.
	INT: After the cessation of your support contract to rural Category B4 municipalities, what has been your observation regarding the municipalities' ability to sustain service provision continuity, particularly in the areas that you have provided support?
	RES: We observed that project quality necessitated the establishment of standards. The majority of problematic systems were not sustainable for non-technical reasons, but rather owing to a lack of financial management, which ranked first on the list of reasons for system failure
	INT: What key success elements of your support can you identify that are associated with building resilient infrastructure management capabilities in rural Category B4 municipalities?
	RES: Compatibility of construction and operating expenses with rural populations' resources and preferences. It is important emphasising that the community does not always choose the lowest cost alternative, but rather a cheaper option that they believe will provide them with a service they are content with and capable of maintaining.
	INT:

	What are pertinent design elements that would contribute towards developing a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES: **I** would say life-cycle planning, budgeting, cost management, contract management

File : Research Interview MISA engineer EC-1

Duration : 0:54:18

Date : 19-09-2022

Acronyms : Interviewer (IN); Respondent (RE)

0:00:00	**INT:** I greatly appreciate your willingness to conduct an interview.
0:00:01	**RES:** No problem!
0:00:02	**INT:** Would you kindly tell me your age bracket? 40-50 50-60 60-70
0:00:02	**RES:** 50-60
0:00:02	**INT:** **How long have you worked in the built environment?**
0:00:03	**RES:** **17**
0:00:04	**What is your highest engineering qualification?**
0:00:04	**RES:**

	B Civil Eng
0:00:05	**INT:** How has your experience been in providing engineering support to the technical employees in the Category B4 municipality?
	RES: What caught my attention was the minimal cost recovery, even for running costs, resulting in a huge chunks of government grant funds for new or upgraded systems being used to simply operate and maintain old schemes.
	INT: What were the fundamental project management practices you employed in scope management, cost management controls, contracts management and monitoring quality on projects, during your deployment in the Category B4 municipality?
	RES:
	INT: What appropriate strategies were you using to identify suitable engineering designs as part of planning & acquisition life-cycle management practice when initiating rural infrastructure projects?
	RES: Infrastructure upgrades and improvements generate some efficiencies; nevertheless, over-design of essential systems frequently negates the benefits. Over-specification and over-design of infrastructure service systems are frequently the result of the incorporation of various design margins.
	INT: After the cessation of your support contract to rural Category B4 municipalities, what has been your observation regarding the municipalities' ability to sustain service provision continuity, particularly in the areas that you have provided support?
	RES: -Timely upgrade (water treatment plants were no longer operating under stress) - Equipment and chemical suppliers still provide backup service
	INT: What key success elements of your support can you identify that are associated with building resilient infrastructure management capabilities in rural Category B4 municipalities?
	RES: - Supervision and management assistance - Operator staffing and training Process management (chemical treating in particular) - Upkeep of equipment and infrastructure
	INT:

0:54:18	What are pertinent design elements that would contribute towards developing a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES: It would have to be contract management, cost control measurement, life-cycle planning

File : Research Interview MISA engineer EC-2

Duration : 0:55:48

Date : 19-09-2022

Acronyms : Interviewer (IN); Respondent (RES)

0:00:00	**INT:** Thank you for consenting to speak with me. I will proceed straight to the questions.
0:00:01	**RES:** You may proceed!
0:00:01	**INT:** Would you kindly tell me your age bracket? 40-50 50-60 60-70
0:00:02	**RES:** 40-50
0:00:03	**INT:** **How long have you worked in the built environment?**
0:00:03	**RES:** **15**
0:00:04	**What is your highest engineering qualification?**

0:00:04	**RES:** B Hons Civil Eng
0:00:05	**INT:** How has your experience been in providing engineering support to the technical employees in the Category B4 municipality?
	RES: Inconsistency of infrastructure of management outcomes to achieve tangible impacts and demonstrate the value of our efforts to stakeholders
	INT: What were the fundamental project management practices you employed in scope management, cost management controls, contracts management and monitoring quality on projects, during your deployment in the Category B4 municipality?
	RES: Capability of managing and negotiating contracts and terms in order to maximise financial and operational performance while minimising risk
	INT: What appropriate strategies were you using to identify suitable engineering designs as part of planning & acquisition life-cycle management practice when initiating rural infrastructure projects?
	RES: - Budgeting for infrastructure within the context of the Medium-Term Expenditure Framework (MTEF); - Emphasis is on scenario planning analysis and process improvement according to the infrastructure management plan
	INT: After the cessation of your support contract to rural Category B4 municipalities, what has been your observation regarding the municipalities' ability to sustain service provision continuity, particularly in the areas that you have provided support?
	RES: Since our support was somewhat not supported politically and not administratively, there was no formalisation and control of all project management processes. Furthermore, the projects office was not separated and didn't have a project-based approach to managing community and municipal problems
0:55:48	**INT:** What key success elements of your support can you identify that are associated with building resilient infrastructure management capabilities in rural Category B4 municipalities?

	RES: Fundamentals of procurement administration and contract management
	INT: What are pertinent design elements that would contribute towards developing a capability maturity framework for infrastructure management resilience in Category B4 municipalities?
	RES: Contract obligation management would have to be combined with project expenditure monitoring.

APPENDIX B – FRAMEWORK

#	Key Capability Improvement Areas (KCIA)	Capility Maturity Levels					
		Level 1 Adhoc	Level 2 Repeatable	Level 3 Defined	Level 4 Managed	Level 5 Optimizing	Level 6 Resilience
	Awareness and understanding of infrastructure management In the technical department, employees should be familiar with infrastructure management. Routine and preventative maintenance of infrastructure is required on a regular basis. Initial thought on capacity maturity models Understanding the ramifications of unreliable service provision for the municipality.	Since there is no consistent environment, no standard capability maturity improvement methods are applied.	Every division water, roads, and solid waste are all making efforts to improve, yet they are not shared.	Standard infrastructure delivery and procurement processes have been established.	Tasks are well known and supported by defined methodss of improvement	Important lessons obtained from past supporting engineers are documented and offered for use within the department.	Continuous ability to manage infrastructure and respond to community service provision and asset maintenance requirements, and ultimately the ability to manage recovery of the affected service delivery divisions beyond the support of engineers deployed in the municipality
1.	Alignment of planning and budgeting	No standard operating procedures and no expertise of infrastructure service delivery budget impelemenation planning	Infrastructure planning resources are not allocated, and there is a large reliance on external knowledge	Overtime the infrastructure departments are adhering to established planning techniques , projects are included in the infrastructure management plan	Emphasis is on scenario planning analysis and process improvement according to the infrastructure management plan	High relevance of infrastructure planning is recognized, and processes are kept up to date.	Alignment of capital and integrated infrastructure planning and investment across three levels of government
2	Budget alignment and infrastructure delivery cycles	Inability to implement planning and budgeting methods and principles, as well as their alignment within the infrastructure delivery cycle	Failure to recognize the budget and time implications of processes that fall outside the actual construction work	Improved collaboration with internal and external stakeholders	Budgeting for infrastructure within the context of the Medium Term Expenditure Framework (MTEF);	Develop a set of decision support tools for improved urban water planning, operations and bulk water management.	Project planned and implemented a s per Medium Term Expenditure Framework (MTEF);
3.	Development of construction procurement documentation	Limited understanding of tenders for procuring infrastructure projects	Improved consistency on supply chain processes	Increased awareness of the supply chain procedures albeit not clearly established.	Recognising the structure of tender and contract documents	Several proforma tendering documents created to assist a consistent approach.	Continuous accessibility to standardised supply chain tools and databases
4.	Procurement administration	The entire procurement administration process is chaotic	Poorly coordinated procurement activities and tendering irregularities	Acquisition choices are coordinated with municipal supply chain bid committees.	Supply chain unit using South African procurement norms & standards	There is a common procedure for keeping processes and records up to date.	Procurement is given high priority, and chaipersons of bid committees report progress to the Municipal Manager.
5.	Value for money in relation to infrastructure delivery	No standard operating procedures and no expertise of infrastructure management.	The formalisation and control of all project management processes; the separation of the projects office; a project-based approach to managing community and municipal problems	The availability of professional registered project managers;	Cooperation and the usage of project portfolio availability;	Timely acesss to services and frequent successful participation in infrastructure project management innovation awards	Relationships with SAICE, MISA, and COGTA maintained with specific instructions on impact-engineering capabilities.
6.	Cost management	No standard template to examine and analyze project-specific potential risks that might result to cost overruns and delays	Frequent budgets and programme overruns	Undestanding of approved budget and variances over project tolerance	Stringent monitoring of project expenditure in relation to the approved budget.	Understanding how to use the WBS level to record costs and track progress against budget	Continuously confirming the project's rand value performance against the total cost and timeline.
7.	Scope planned versus scope performed	No standard templates for scope change control to manage change requests that can prevent scope creep	Limited understanding of project deliverables to steer clear of future scope creep	Adherence to project baseline and boundary conditions, which cannot be changed without the approval of the project director	Stringency of project approved budget and scope	Internal workflow automation to quickly break down down project goals into tasks	Continuous advancement through innovation and improvements in technology
8.	Contract Management	Lack of knowledge of the GCC and JBCC, resulting in inadequate contractual change settlement. - Performance issues as a result of disagreement over the performance description -	Strigency to meet agreed-upon performance standards owing to project budget, scope and time commitment -	Poorly applicable contract- or service structure - Pricing disagreements - Subcontractor issues		Availability of data on infrastructure projects, including project charters, progress reports, and final reports with lessons learned	
9.	Risk and liability Management	Inability to identify potential risks and their magnitude, ensuring that that the proper action is taken by the right persons,	No standardised acquisition processes and practices				
10.	Compliance management	No compliance management checklist for limiting construction liabilities and, ultimately, avoid the legal and financial repercussions of non-compliance by contractors & consultants	Execution conformity to norms & standards		Consistency of infrastructure management outcomes with the developed water plan, we can achieve tangible impacts and demonstrate the value of our efforts to stakeholders		
11.	Determination on scope & budget variation orders	No standardard processess to deal with detrimental VO's on cost overruns and time overruns					
12.	Construction quality audits	No standard quality control plan audit for projects under construction		Number of projects that have regular project quality assessments			
13.	Life cycle asset Operation & Management	Limited knowledge of the engineering life cycle and reliability- centred maintenance standard procedures	Limited know-how technical, administrative, and managerial tasks designed to keep it in a good state of repair	Structured procedures, tools, and methodologies for project planning and design, budgeting and execution, and operations and maintenance.	Maintenance is handled on an individu al basis.	Well calculated unit costs of capital and maintenance activities, failure impact, and current equivalent replacement costs	Reliability-centered maintenance (RCM) concentrates on developing a systematic, comprehensive maintenance strategy that utilizes the benefits of preventive, predictive, and corrective maintenance procedures in order to maximize equipment reliability, save costs, improve service provision
14.	Risk reduction, risk transfer, risk retention and risk mitigation strategies	No template to deal with infrastructure implementation issues include risks associated with on-site construction activities			There is focus on continual		

APPENDIX C - COVER LETTER FOR CONCEPTUAL FRAMEWORK VERIFICATION BY THE EXPERT PANEL

Capability maturity framework for resilient infrastructure management in the Category B4 municipalities

Dear Participant,

Thank you so much for consenting to being a participant in this research's expert forum.

The recently performed questionnaire analysis is now complete. The recently performed questionnaire analysis is now complete. The aim of this stage is to verify the resilience capability areas before including them as part of the components of the capability maturity framework.

Kindly refer to the attached instruction sheet for the details of expectations.

The following documents are attached:

1. Instructions to experts

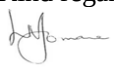
2. General capability maturity areas mapped from the knowledge areas

3. Conceptual capability maturity framework

It would be greatly appreciated if you would submit document 'A' by sending an email on Friday, February 24th, 2023. If you require additional information, please email the research team. Please rest assured that all information gathered will be kept strictly confidential.

Your decision to participate in the expert forum is highly appreciated.

Kind regards,



Luyanda Ngomane

APPENDIX D - EXPERT GUIDE TO VERIFY CAPABILITY AREAS

Capability maturity framework for resilient infrastructure management in the Category B4 municipalities

Instruction to experts

The aim of this phase is to verify the key capability areas before they are included as components of the capability maturity framework.

(Kindly read through all the instructions carefully)

1. Read carefully the listed capability areas (See Section 3 on the conceptual framework and Table 5 to in the body of this thesis). Table 5 will give the list of capability areas that must be verified and section 3 will give you a better grasp of the unique characteristics of each maturity level (Maturity level 1 - Adhoc to Maturity level 5 - Optimizing).

2. Once the capability areas are verified and commended, thereafter the capability maturity framework for resilient infrastructure management will be developed

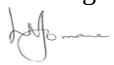
3. On Table 6 clearly indicate your thoughts on the adequacy of every capability area by providing a verification outcome and comments.

4. Please provide other comments on the key capability areas that must be included in the development of the capability maturity framework

5. Kindly return the completed table 5 via email by Thursday, 24 February 2023

Your participation in this study is highly appreciated.

Kind regards,



Luyanda Ngomane

APPENDIX E – ETHICS COMMITTEE APPROVAL

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Ngomane

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H21/10/36**
PROJECT TITLE	Design of a Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa
INVESTIGATOR(S)	Mrs L Ngomane
SCHOOL/DEPARTMENT	School of Construction Economics and Management/
DATE CONSIDERED	22 October 2021
DECISION OF THE COMMITTEE	Conditionally Approved Permission letters required from all municipalities involved before data collection can commence Risk Level: Minimal
EXPIRY DATE	30 November 2024

DATE 01 December 2021 **CHAIRPERSON** J. Knight
(Professor J Knight)

cc: Supervisor : Professor N Khatleli

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

Ngomane 3, 12, 2021

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX F - PERMISSION TO CONDUCT RESEARCH – MNGUMA MUNICIPALITY

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

The Municipal Manager
Mnquma Local Municipality
Topblyth Street Butterworth
4960

Date: 3 December 2021

Dear Sir/Madam

Re: Permission to conduct research at Mnquma Local Municipality

My name is Luyanda Ngomane I am a PhD in Construction Management research student, registered at the University of the Witwatersrand, School of Construction Economics and Management. I am seeking permission to do research at Mnquma Local Municipality.

I am conducting research on Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa. This topic was chosen having reviewed literature on previous engineering support programmes to improve infrastructure management (IM) capabilities in Category B4 municipalities. These studies found that these support initiatives were not effective or rather lacked the resilience component as part of the support model. Hence, the objective of this research is to assist the Category B4 municipalities recognize their present engineeringcapabilities and the recommended improvement pathway towards resilience. The study incorporates the resilience stage in the design parameters for suitability in Category B4 municipalities, as capability improvement tools and models ought to be rooted in and linked to the dynamic organizational circumstances. Mnquma Local municipality is one of the Category B4 municipalities in the Eastern Cape province. I will invite individuals in the engineering/technical services department from your organisation to participate in this study. If they agree, they will be asked to be interviewed during work hours and also be part of focus group discussions. These semi-structured interviews will take around 60 minutes. These interviews will be onlinedue to Covid restrictions, however, where feasible

face-to face interviews will be conducted. The respondent's responses will be audio recorded and the recordings will be stored in password protected computer and on-line data base (Google OneDrive). Only the researcher will have access to this recording. It will be deleted after five years. Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous unless otherwise expressly indicated.Individual privacy will be maintained in all published and written data resulting from thestudy.

The study results will be communicated in the dissertation and published on academicjournals. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time duringthis project without any penalty. There are no foreseeable risks in participating in thisstudy. The participants will not be paid for this study.

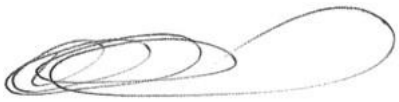
All research data will be preserved anonymously for reuse by other researchers.

I therefore request permission in writing to conduct my research at your municipality. The permission letter should be on your municipal letterhead, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Luyanda Ngomane
Cell: 0832753262
Email: 1342665@students.wits.ac.za



Supervisor: Prof Nthathisi Khatlel
iContact No: 011 – 717 7651

APPENDIX G - PERMISSION TO CONDUCT RESEARCH – MHLONTLO MUNICIPALITY

MHLONTLO LOCAL MUNICIPALITY

POSTAL ADDRESS
P.O. Box 31
Qumbu
5180

PHYSICAL ADDRESS
96 LG Mabindla Street
Qumbu
5180

E lfoni/Tel: 047 553 7000
Email: sbatyi@mhlontlolm.gov.za

Date: 02 February2022

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

Date: 28 January 2022

Dear Ms Luyanda Ngomane

Re: Permission to conduct research at Mhlonto Local Municipality – Design of Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa

Your request for permission to conduct research within our municipality is hereby granted. Your chosen topic on the Design of Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa, is so relevant to our municipality, moreso that we are amongst those still faced with infrastructure management challenges.
Hereunder are the details of our Manager: Technical Services whom you can contact for the data collection processes: Ms Petse -063 686 7225

We so looking forward to the findings that would come out of this study, and how the final recommendations would benefit this municipality.

Yours sincerely,

.....

Ms S Bhatyi
Acting Municipal Manager

APPENDIX H – PERMISSION TO CONDUCT RESEARCH – MNQUMA

MNQUMA
LOCAL MUNICIPALITY

Mnquma Local Municipality • Corner King and Mthatha Street • Butterworth • 4960
Postal Address: • PO Box 36 • Butterworth • 4960
Tel: (047) 401 2400 • Fax: (047) 491 0195 • www. mnquma.gov.za

Date: 21 January 2022 | **Person dealing with the matter:** Silumko Mahlasela– Municipal Manager | **Ref:** 4/3/2

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

To: **Ms Luyanda Ngomane**

Cell: 0832753262

Email: 1342665@students.wits.ac.za

RE: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY IN MNQUMA LOCAL MUNICIPALITY

The above matter bears reference

This serves to acknowledge your letter received by my office on the 11 January 2022 wherein you stated that you are currently doing a PhD in Construction Management, registered at the University of the Witwatersrand, School of Construction Economics and Management and you are seeking permission to do research at Mnquma Local Municipality.

You are hereby granted the permission to conduct your research on **Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa** at Mnquma Local Municipality.

Regards

MUNICIPAL MANAGER
S MAHLASELA

MNQUMA MUNICIPALITY
P.O. BOX 36, BUTTERWORTH 4960
2022 -01- 21
MUNICIPAL MANAGER

APPENDIX I – PARTICIPANT INFORMATION SHEET – EXPERT FOCUS GROUP

Participant Information Sheet – Expert Focus Group

Title: Design of a Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa
Dear Sir/Madam

My name is LUYANDA NGOMANE and I am a PhD candidate in the School of Construction Economics and Management at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project titled, ***Design of a Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa.*** I am investigating Capability Maturity Models, incorporating the resilience stage in the design parameters, for suitability in Category B4 municipalities, under the supervision of Prof NTHATISI KHATLELI. The aim of this research project is to develop a capability maturity framework for resilient infrastructure management in Category B4 municipalities'.

As part of this project, I would like to invite you to take part in an expert focus group discussion. This activity will be conducted through unstructured interviews scheduled for 90 minutes. With your permission, I would also like to audio record the interview using a digital device. These interviews will be online due to Covid restrictions, however, where feasible face-to face interviews will be conducted. This recording will be stored in password protected computer and on-line data base (Google OneDrive), only the researcher will have access to this recording. It will be deleted after five years.

There will be no personal costs to you if you participate in this project, you will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you (optional). The data collected from this research project will be stored in password protected computer and on-line data base (Google OneDrive), and will be kept for five years. With your permission the data collected from this research project may be used by other researchers in an anonymized format.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon- medical@wits.ac.za

Yours sincerely,
Luyanda Ngomane Researcher:

Luyanda Ngomane, Wits email: 1342665@students.wits.ac.za, Cell: 083 275 3262

Supervisor:
Prof Nthatisi Khatleli, Nthatisi.Khatleli@wits.ac.za, 011 -717-7651

APPENDIX J – PARTICIPANT INFORMATION

OFFICE OF THE MUNICIPAL MANAGER

UMZIMVUBU
LOCAL MUNICIPALITY

ERF 813 Main Street, KwaBhaca 5090 Private Bag X 9020, KwaBhaca 5090
Phone: 039- 255 8500 Fax: 039-255 1893
E-Boyce.Ncumisa@umzimvubu.gov.za

03 February 2022

University of the Witwatersrand
School of Construction Economics &Management
1Jan Smuts Avenue, Braamfontein
JOHANESBURG
2050

Per Email: 1342665@students.wits.ac.za

Dear Luyanda / Prof. Nthathisi Khatleli

RE: PERMISSION TO CONDUCT A RESEARCH ON CAPABILITY MATURITY FRAMEWORK FOR RESILIENT INFRASTRUCTURE MANAGEMENT IN CATEGORY B4 MUNICIPALITIES IN SA - UMZIMVUBU LOCAL MUNICIPALITY.

The above subject matter bears reference.

This serves to acknowledge receipt of your letter dated 01st of February 2022, that requests a permission to conduct a research study entitled: **Capability Maturity Framework for Resilient Infrastructure Management (IM).**

It is with great pleasure to inform you that Umzimvubu Local Municipality as category B4 Municipality in Eastern Cape, under Alfred Nzo District Municipality grants you a permission to conduct the above-mentioned study.

The Municipality have read the project objectives with the understanding that:

- All the information obtained will be treated in strictest confidence.
- Only members who consent will participate in the Research Project.
- The participant's names will not be used, and individual participants will not be identifiable in any written reports about the study.

Yours Faithfully.

GPT NOTA
MUNICIPAL MANAGER

APPENDIX K – PERMISSION TO CONDUCT RESEARCH – MT FRERE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

The Municipal Manager
813 Main Street
Mount Frere
5090

Date:

Dear Sir/Madam,

Re: Permission to conduct research at Mt Frere Local Municipality

My name is Luyanda Ngomane I am a PhD in Construction Management research student, registered at the University of the Witwatersrand, School of Construction Economics and Management. I am seeking permission to do research at Mt Frere Local Municipality.

I am conducting research on Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa. This topic was chosen having reviewed literature on previous engineering support programmes to improve infrastructure management (IM) capabilities in category B4 municipalities. These studies found these support initiatives were not effective or rather lacked the resilience component as part of the support model. Hence, the objective of this research is to assist the category B4 municipalities recognize their present engineering capabilities and the recommended improvement pathway towards resilience. The study incorporates the resilience stage in the design parameters for suitability in category B4 municipalities, as capability improvement tools and models ought to be rooted in and linked to the dynamic organizational circumstances. Mt Frere Local municipality is one of the category B4 municipalities in the Eastern Cape province.

I will invite individuals in the engineering/technical services department from your organisation to participate in this study. If they agree, they will be asked to be interviewed during work hours and also be part of focus group discussions. These semi-structured interviews will take around 60 minutes. These interviews will be online due to Covid restrictions, however, where feasible face-to face interviews will be conducted. The respondent's responses will be audio recorded and the recordings will be stored in password protected computer and on-line data base (Google OneDrive). Only the researcher will have access to this recording. It will be deleted after five years.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

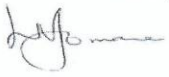
The study results will be communicated in the dissertation and published on academic journals. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

All research data will be preserved anonymously for reuse by other researchers.

I therefore request permission in writing to conduct my research at your municipality. The permission letter should be on your municipal letterhead, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,



Luyanda Ngomane
Cell: 0832753262
Email: 1342665@students.wits.ac.za

Supervisor: Prof Nthathisi Khatleli
Contact No: 011 – 717 7651

APPENDIX L – PERMISSION FROM MORETELE MUNICIPALITY

MORETELE LOCAL MUNICIPALITY

OFFICE OF THE MUNICIPAL MANAGER

Address all Correspondence to the Municipal Manager

Reference: Permission to conduct research Enquiries: Sentle Moreriane

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

Date: 14 February 2022
Attention: Ms Luyanda Ngomane

Re: Permission to conduct research at Moretele Local Municipality – Design of Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa

Your request for permission to conduct research within our municipality is hereby granted. Your selected topic on the Design of Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa, is relevant to our municipality with respect to our emphasis on sustainable service delivery models.
Hereunder are the details of our Acting Infrastructure Development & Services whom you can contact for the data collection processes: Mr P. Molautsi at *pholosho.molautsi@moretele.gov.za* or 076 291 5878.

May you kindly share with us the findings that would come out of this study. We also looking forward with keen interest the final recommendations.

Yours sincerely,

.....

Mr Sentle Moreriane
Acting Municipal Manager

Private Bag X367, Makapanstad 0404, Municipal Offices: 4065B MathibestadTel: 012 716 1301 Fax to Email: 086 5513 855 / 086 551 4027

APPENDIX M – PERMISSION FROM NYANDENI MUNICIPALITY

NYANDENI LOCAL MUNICIPALITY

PHYSICAL ADDRESS:
Municipality Building
B.N. Nomandela Drive
LIBODE
POSTAL ADDRESS:
Private Bag X 504
LIBODE
5160

N.L.M.
NYANDENI LOCAL MUNICIPALITY

Tel: 047 5555 000
047 5550 281

Fax: 047 555 0202

Email:
nyandeni@nyandenimun.org.za

"Deciding with the people, not for the people"

25 January 2022

Mrs. Luyanda Ngomane
19 New York Road
Thorn Valley Estate
Greenstone
1616
South Africa

Dear Mrs. L. Ngomane

APPROVAL TO CONDUCT RESEARCH: PHD Thesis: Construction Management

Kindly be advised that your request to collect data at Nyandeni Local Municipality has been granted and you may commence with your research in due time.

It should be emphasised that you are expected to maintain strict confidentiality, observe professionalism and ethical consideration when conducting your research.

You are encouraged to contact the office of the Mrs. N. Mqoqi-Mondi: Senior Manager Infrastructure Development Services to assist you in the process, email: **mondin@nyandenilm.gov.za**

Yours in Developmental Local Government

.....
MS. Z. MASUMPA
ACTING MUNICIPAL MANAGER

Page **1** of **1**

APPENDIX N – PERMISSION TO CONDUCT RESEARCH NYANDENI

University of the Witwatersrand
School of Construction Economics and Management
Faculty of Engineering and the Built Environment
University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein
Johannesburg
2050

The Municipal Manager
Nyandeni Local Municipality
Nomandela Drive
Libode
5160

Date:

Dear Sir/Madam,

Re: Permission to conduct research at Nyandeni Local Municipality

My name is Luyanda Ngomane I am a PhD in Construction Management research student, registered at the University of the Witwatersrand, School of Construction Economics and Management. I am seeking permission to do research at Nyandeni Local Municipality.

I am conducting research on Capability Maturity Framework for Resilient Infrastructure Management in Category B4 Municipalities in South Africa. This topic was chosen having reviewed literature on previous engineering support programmes to improve infrastructure management (IM) capabilities in Category B4 municipalities. These studies found these support initiatives were not effective or rather lacked the resiliencecomponent as part of the support model. Hence, the objective of this research is to assist the Category B4 municipalities recognize their present engineering capabilities and the recommended improvement pathway towards resilience. The study incorporates the resilience stage in the design parameters for suitability in Category B4 municipalities, as capability improvement tools and models ought to be rooted in and linked to the dynamic organizational circumstances. Nyandeni Local municipalities is one of the Category B4 municipalities in the Eastern Cape province.

I will invite individuals in the engineering/technical services department from your organisation to participate in this study. If they agree, they will be asked to be interviewed during work hours. These semi-structured interviews will take around 60minutes. These interviews will be online due to Covid restrictions, however, where feasible face-to face interviews will be conducted. The respondent's responses will be audio recorded and the recordings will be stored in password protected computer and on-line data base (Google OneDrive). Only the researcher will have access to thisrecording. It will be deleted after five years.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names andthe name of the organisation) will be anonymous unless otherwise expressly indicated.Individual privacy will be maintained in all published and written data resulting from thestudy.

The study results will be communicated in the dissertation and published on academicjournals. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time duringthis project without any penalty. There are no foreseeable risks in participating in thisstudy. The participants will not be paid for this study.

All research data will be preserved anonymously for reuse by other researchers.

I therefore request permission in writing to conduct my research at your municipality. The permission letter should be on your municipal letterhead, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Luyanda Ngomane
Cell: 0832753262
Email: 1342665@students.wits.ac.za

Supervisor: Prof Nthathisi Khatleli
Contact No: 011 – 717 7651