PROPERTY AND MAINTENANCE MANAGEMENT FRAMEWORK FOR NEW ZEALAND'S STATE SCHOOLS

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Abstract

School buildings are considered fundamental elements of any community. The buildings and infrastructure are not only supposed to provide a pleasant and safe environment for staff and students, but they are also a clearly visible presentation of the education system. As a result, it is crucial to ensure that school property is well maintained through proactive management. In New Zealand (NZ), state school property is owned by the Ministry of Education (MoE) and managed and operated by the school board of each school with the assistance of external consultants. This research aims to develop a framework that helps those involved in managing school buildings and infrastructure in New Zealand's state schools by improving collaboration among the key stakeholders. Previous research on managing existing property and associated theoretical concepts, such as asset management, property management, maintenance management, stakeholders' involvement, and maturity model frameworks, were reviewed to identify research problems.

In order to refine the research objectives, a preliminary study was conducted that involved the researcher attending training courses on property and maintenance management to understand processes, make connections, conduct interviews with other attendees, and distribute a survey among them. Findings from the preliminary study highlighted the central role of stakeholders' collaboration for the provision of efficient property and maintenance management, but other issues were also identified. A further in-depth study based on interviews with school managers was undertaken to cover the current activities and processes, challenges, roles, and responsibilities of the key stakeholders in managing existing buildings and infrastructure in state schools in New Zealand. Based on findings from the literature review and interviews, a maturity assessment model was developed. A questionnaire was distributed to explore the maturity levels of different management processes currently in place to identify the priorities

for process improvement actions. The maturity level scores revealed the most needed improvement areas that the key stakeholders should focus on, including the reporting system, performance evaluation, staff training, lesson sharing, communication, and continuous improvement. In addition, Partial Least Squares Structural Equation Modelling (PLS-SEM) approach was used to explore the relationships among key stakeholders and test the research hypotheses. The results of the PLS-SEM assessment prove that there are undeniable relationships between the key stakeholders. It also highlighted that all stakeholders are responsible to work closely as a team as they have both direct and indirect effects on each other's performance. Close teamwork contributes to the overall outcome of property and maintenance management for NZ's state schools.

A property and maintenance management framework for NZ's state schools was then developed based on the findings of the literature review and data analysis using the key concepts of the Plan-Do-Check-Act cycle. The proposed framework comprises five stages (Establish, Plan, Implement, Evaluate, and Improve - E-PIE-I, and shortened to PIE) and includes activities in each stage. More activities were added in the Establish phase in order to address the need to provide staff training programmes and improve the collaboration between people involved in the processes. Moreover, the proposed PIE features a feedback loop in the Evaluate and Improve stages which helps assess performance of the processes and obtain feedback and learning outcomes for continuous improvements. Validation interviews with school managers were conducted, and the results show that the PIE framework could help improve property and maintenance management for New Zealand's state schools.

The research contributes to the property and maintenance management field, focusing on the collaboration between the people involved in the process. The research also reveals other challenges and issues in managing school property in state schools and proposes solutions to overcome these challenges. More importantly, this research produces a set of diagrams in the PIE framework, which can be used as guidelines for school managers and other stakeholders to perform their roles effectively. The study finally produces recommendations for improvements in managing school property at both the school level and the MoE level. The findings should be of interest to top management, schools, service providers, and researchers dealing with the management of existing buildings and infrastructure in schools.

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"Con xin gui loi biet on toi su tin tuong tuyet doi cua bo me vao su lua chon cua con. Su tin tuong cua bo me la nen tang, la nguon dong vien tinh than vo cung quan trong voi con, ma khong loi nao co the dien ta het. Con/chau xin gui loi cam on chan thanh nhat toi gia dinh va ho hang hai ben da luon quan tam va dong vien con/chau tren con duong gian nan nay. Xin cam on anh chi em, ban be da thau hieu va dong vien em/minh. Vai loi khong the noi het, hen gap lai tai Vietnam!"

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Abbreviations

10YPP	10-year Property Plan
5YA	5-Year Agreement
AM	Asset Management
AVE	Average Variance Extracted
CMM	Capability Maturity Model
E-PIE-I	Establish - Plan - Implement - Evaluate - Improve
CR	Continuous Representation
ISO	International Asset Management Standard
NAMS	National Asset Management Steering
PA	Property Advisors
PDCA	Plan - Do - Check - Act
PM	Project Managers
PMG	Property Maintenance Grant
PO	The Ministry Property board
PP	Property Planners
OPG	Operational Grant
SC	School Boards
PLS	Partial Least Squares
PMMS	Property and Maintenance Management for State Schools
SEM	Structural Equation Modelling
SR	Staged Representation
VIF	Variance Inflation Factor

Chapter 1

Introduction

1.1 General introduction

This chapter introduces the context for this research study. It starts with a brief overview of the background to the research and the justification for the research. This is followed by the aim and objectives of the study and a brief summary of the research methodology. The chapter concludes with the structure of the thesis and an outline of different chapters.

1.2 Background

The concept of managing existing buildings and infrastructure has evolved and there is growing attention to the need to maximise resources used for maintaining buildings and infrastructure during their operation phase. Traditionally, managing existing buildings and infrastructure has solely involved repairing and replacing components. Recently, with the development of the asset management concept, managing existing buildings and infrastructures, as with other physical assets, has become a multidisciplinary task and has a significant impact within the organisation in terms of balancing of cost, risks, opportunities, and performance benefits (ISO 55000, 2014). Asset management is increasingly important to all types of organisations, such as governments as well as private, public and not-for-profit organisations. Many frameworks have been developed to enable organisations to achieve their objectives through the using of their assets. An International Asset Management Standard, the ISO 55000 series, was introduced to provide a global framework for managing the use of physical assets. The series

introduced the structure, requirements, and stakeholder expectations of an asset management system. Unfortunately, the ISO 55000 series mostly outlined what asset management must have, meaning that organisations needed to decide themselves how to build an asset management system in relation to achieving their business objectives and operate the system successfully. As the literature review presented in Chapter 2 shows, many organisations have adopted the ISO 55000 framework for their asset management (International Union of Railways, 2016; Lifetime Reality Solution, 2014); however, several challenges still exist such as data and process are fragmented, people involved are working on their own agendas and performance measures without alignment of objectives and resources, and conflicts and de-motivation are increased between team members (The Institute of Asset Management, 2015).

In public sector, asset management of school buildings and infrastructure is more important as it provides a pleasant, free hazard and safe environment for teaching and learning (Trachte and De Herde, 2015). Previous studies suggested that failing to maintain school buildings appropriately can lead to facilities deteriorate and also discourages future investment in the education system (Kennedy, Mike, 2012; US Department of Education, 2003). Therefore, governments spend huge amount on keeping school properties in good shape. Department National Treasury-Republic of South Africa (2015) reported that expenditure on education was an average of 6.2% of the gross domestic product (GDP) in 2014/2015 and 79.3% of the budget were payments for capital asset. The report also suggested that these spending on education ratios are favourably when compared with other developing and middle-income countries. In the UK, the average annual running cost of secondary schools is of £65 per m^2 of gross internal floor area, covering maintenance, decoration, cleaning, energy and other utilities (Royal Institution of Chartered Surveyors, 2018). In New Zealand, the school property portfolio is the second largest property portfolio in NZ and it is reported that NZD 906 millions of capital expenditure was spent on school property in 2018/2019 (Ministry of Education, 2020). Because of the importance of the school property system, research has been conducted to ensure that school properties are maintained effectively and efficiently.

Managing existing school buildings and infrastructure usually involves different parties with different interests and abilities such as property owners, service providers, school boards, and authorities. The literature review confirms

that effective management requires an appropriate organisational structure and collaboration between people involved due to a large range of responsibilities (Earthman and Lemasters, 2013). The term collaboration has been defined as the way in which different parties working together towards a common goal (Hughes et al., 2012). However, merely bringing a group of participants to work together does not ensure successful collaboration. Chan et al. (2003) indicated common problems in collaboration in the construction industry, such as misunderstanding of the collaboration concept, relationship problems, and communication problems. While most collaboration frameworks have been explored for new building projects (Akintan and Morledge, 2013; Faris et al., 2019), the collaboration problems in managing existing buildings, especially in the context of schools, have not been fully investigated. There is a shortage of research on relationships between the people involved in the decision-making process and procedures for managing school buildings and infrastructure.

Various assessment methods have been developed to analyse how the management of existing buildings and infrastructure is currently practised in organisations. Recently, the maturity model concept has been introduced to guide organisations in the assessment of their current state by comparing the best practices and the quality standards of the organisation to others (The Institute of Asset Management, 2014). The Capability Maturity Model (CMM) is one framework that has been developed to measure maturity levels of processes or activities of service providers. The framework has been implemented in many disciplines, and has achieved great success and benefits. In the field of asset management, many organisations are using the CMM framework to assess their asset management system (Sharp, 2013; The Institute of Asset Management, 2014). There are different assessment frameworks, developed from CMM, that will allow organisations to assess their maturity level and help them find the best approach to achieving excellence. Results of the assessment help identify performance gaps between the organisation's asset management performance and the good/best practice nationally and internationally to guide them on their maturity path.

This research explores the practice of managing existing buildings and infrastructure in state schools in New Zealand, focusing on how people involved are working together to achieve the defined objectives. The aim of this research, as will be explained later, focuses on enabling the key stakeholders to understand the fundamental issues existing in key processes and procedures for managing

that buildings and infrastructure. This research plans systematically develop solutions to solve the challenges and at the same time increase the maturity level of the system.

1.3 Research justification

It is critical that school properties should be well managed to provide a comfortable physical environment supporting good educational outcomes and to increase the public's confidence in the education system (Abdelhamid et al., 2013; Ministry of Education, 2011; Trachte and De Herde, 2015). As a result, academic and practical interest in building and maintenance management for schools has increased substantially (Akasah et al., 2010; Ampofo et al., 2020). For example, research was conducted focusing on the technical aspects of managing school buildings such as ventilation and indoor air quality issues (Fisk, 2017; Wang et al., 2016), energy performance (Di Giuda et al., 2015; Mohelníková et al., 2020), refurbishment and renovation (Al Bunni and Shayesteh, 2019; Le, Park, Domingo, Rasheed and Mithraratne, 2018), and maintenance management processes (Akasah et al., 2010). Similarly, in NZ, although there have been attempts to conduct research on school buildings, the research is limited, and the topics centered on indoor air quality and energy assessment (Bennett et al., 2019; Trompetter et al., 2018; Wang et al., 2016).

An in depth review of literature to date suggest that while decisions on managing school buildings and infrastructure are both technical and managerial, there is very little consideration of the managerial perspective in the literature review (Olanrewaju and Abdul-Aziz, 2015). Although several guidelines and frameworks have been developed for school building maintenance management, they center on planning, implementation of the maintenance plans, costs of maintenance and budgeting for maintenance (Earthman and Lemasters, 2013; Kennedy, Mike, 2012; Royal Institution of Chartered Surveyors, 2018; US Department of Education, 2003). However, a small number of attempts were made to establish models to examine relationships among key stakeholders in relation to promoting the improvement of property and maintenance management.

In addition to addressing technical issues, since managing school buildings usually requires an interdisciplinary team working together towards common goals, it is essential to explore how key stakeholders in this field collaborate.

Especially in the context of state schools, school managers are managing school properties on behalf of another party (state, local council). However, they often lack professional knowledge in property and maintenance management so they often rely on external consultants or service providers. Previous studies have proven that effective managing school properties requires the understanding and collaboration of internal and external stakeholders ensuring achievement of the common goals (Au-Yong et al., 2017; Reymen et al., 2008). Therefore, there is a need to explore how they are organised, and to examine the relationships between the stakeholders. Although the roles and responsibilities usually are defined in an organisational chart, there is a lack of understanding of their influences and how well they work together.

In New Zealand (NZ), the state school property portfolio is the second largest publicly-owned portfolio of property assets in NZ. There are nearly 2,100 state schools with over 15,000 buildings and 35,000 classrooms serving approximately 750,000 students (Ministry of Education, 2020). Seventy percents of school buildings are between 30-100 years old, and the average age of state school buildings is 42 years (Ministry of Education, 2017). Buildings of this age require appropriate management to provide a safe and clean environment for teaching and learning. In 2011, the Ministry of Education published a report, re-issued in 2020, on its NZ school property strategy with the aim "to improve the quality of school property and the system of property management, and to deliver greater value for money in the long term" (Ministry of Education, 2020). The strategy also highlighted the critical role of property management in ensuring that school property contributes to educational outcomes in schools in NZ. Therefore, there is a need to conduct research aims at developing frameworks to assist those involved in managing their school property effectively. In addition, the strategy report focused on four strategic goals: 1) School property meets agreed standards to support learners; 2) Policies, planning and investment optimise long-term social, environmental and economic benefits; 3) Everyone knows their role in managing school property and is supported to deliver; and 4) Diversity is recognised, and schools and learners with the greatest needs are prioritised. One of the priority areas for achieving these goals is to assess the current practice and to provide key stakeholders with full details of school property management processes, an understanding which will enable them to identify challenges and systematically develop solutions accordingly. Although the strategy is well developed, there is

a lack of understanding of maturity assessment of roles and responsibilities in managing school properties.

The state school properties in NZ are owned by the Ministry of Education (MoE), and managed and operated by the school boards with assistance from external consultants. Those involved in the management are Ministry property board (PO), property advisors (PA), school managers (SC), and external consultants (property planners- PP, and project managers - PM). Most school boards and principals are not specialists in property management and they often rely on the Ministry advisors and external consultants to manage their school buildings and infrastructure (Controller and Auditor, 2017; Ministry of Education, 2020). Therefore, managing school property in NZ is naturally complicated as a result of the large number of stakeholders involved, and their diversity of interests, different ideas, expectations, and abilities. It is critical that all people involved clearly understand about their roles and responsibilities in school property management and how to collaborate to achieve the common goals. Moreover, property and maintenance management process can be described as fragmented process due to key stakeholders being based in different organisations resulting in limited benefits of communication. If people involved do not actively collaborate, they may not be able to create a shared vision for a long-term plan and maximise the value of the school property management. Therefore, there is a need to develop a holistic framework supporting the stakeholders with detailed activities, relationships between the activities and the involvement of the stakeholders across all activities in managing school properties.

1.4 Research aim and objectives

The primary aim of this research is to develop a framework which aids stakeholders of state schools in NZ to manage their property maintenance effectively. In this pursuit, the following objectives are considered. **Objective 1** is to review theoretical concepts and previous work on property and maintenance management for schools in the context of asset management, which allow the researcher to identify the research gaps in this field. Achievement of the objective 1 by reviewing the existing models and frameworks also provide the researcher an opportunity to learn from the best practice and establish research questions for this study. Subsequently, **Objective 2** is to investigate the practice in school property

and maintenance management in NZ including processes, roles, responsibilities, challenges. Achievement of the objective 2 provides an overview of how school property and maintenance management are implemented and what are factors hindering the effective management. Based on that, the research hypotheses were stated for statistical testing purposes. The statistical testing results also examine the relationships of stakeholders involved to evaluate their impacts on each other. Because state budget is always limited, therefore, **Objective** 3 is to determine the most needed improvement areas for addressing these challenges by using maturity model framework. Finally, this study is designed to assist key stakeholders provide better school property and maintenance management. Therefore, **Objective 4** is to establish and validate a framework providing key stakeholders a better understanding about activities, processes and standards to perform their roles and responsibilities effectively in school property management. At the same time, the framework also improve the maturity level of school property system. In short, the research objective are as follows:

- Objective 1: To review theoretical concepts and previous work on property and maintenance management for schools in the context of asset management.
- Objective 2: To investigate the practice in school property and maintenance management in NZ including processes, roles, responsibilities, and challenges.
- Objective 3: To evaluate maturity level of the responsibilities and determine the most needed improvement areas in school property and maintenance management.
- Objective 4: To establish and validate a framework assisting stakeholders of state schools in NZ to manage their property maintenance effectively.

1.5 Research methodology overview

To achieve the objectives above, this study need to explore the practice of school property and maintenance management and demonstrate the relationships among the key stakeholders to develop a new framework. For this purpose, it requires the collection of data on the current practices and findings from data analysis were used to develop a theory for this study. This theory then was tested against

the existing data. As a result, this study has been led by a combination of inductive and deductive approaches. The study used inductive reasoning at the start to build patterns and theories on the relationships of the key stakeholders and then used a deductive approach to test the hypotheses, leading to the confirmation of the theories. Based on the selection of combination of inductive and deductive approaches, a multi-phase mixed methods approach was employed for this study. The research objectives will be addressed in five steps: literature review, preliminary study and interviews, questionnaire survey, design of developed framework, and finally its validation. The research methods, techniques, and research outcomes of each phase are presented in Figure 3.4.

Literature Review: This research starts with a comprehensive literature review focusing on the areas of building maintenance, asset management, maturity model framework, and the context of school building maintenance management in New Zealand to achieve Objective 1. A literature search was undertaken using electronic and printed sources, and using the "snowball" technique. This means that the search was gradually extended through the references and key authors within the discovered literature. Additionally, a review of research methods was undertaken to identify the most suitable methodology for this research.

Preliminary Study and Interviews: As the researcher has not worked in the school property management, taking field trips in preliminary study were activities that allowed the researcher to immerse herself into the environment to gain an understanding of the unfamiliar environment and processes. Both participating in training courses as well as discussing the research with the participants in the training courses helped the researcher to justify the significant of the research, and thus helped her identify areas for further study.

The findings of the field trips and the literature review were used to develop semi-structured questions for interviews to fulfil Objective 2. Findings from the interviews capture the activities, processes, roles and responsibilities that are relevant in the school property management. Current challenges were also investigated and hypotheses were stated. The findings of the interviews were used to develop the questionnaire survey to assess the maturity level of school property management and examine relationships between key stakeholders involved.

Questionnaire Survey: This research employed maturity model framework to assess maturity level of roles and responsibilities in school property and maintenance management in NZ's state schools. Overall, 185 participants responded

to the questionnaire. A total of 148 valid answers (140 school board members and 8 Ministry advisors) were used for the data analysis. The results revealed the maturity level of the roles and responsibilities in school property and maintenance management. Structural equation modelling (SEM) approach via Partial Least Squares analysis (PLS-SEM) were used to analyse the data and identify relationships among the key stakeholders. Results were used to recommend the most needed improvement areas to achieve higher maturity levels in school property and maintenance management in NZ's state schools.

Framework Development: Based on the findings from the literature review, preliminary study, interviews, and questionnaire data, the new framework was proposed to achieve Objective 4. A set of activities with inputs, outputs, controls, and the people who perform the activities are presented in this proposed framework. The activities were categorised into five stages: Establish, Plan, Implement, Evaluate and Improve (E-PIE-I). This research used Integrated Function Modelling language with boxes and arrows to present the relationships between the activities and elements of property and maintenance management for schools.

Validation: The validation study explored the potential implementation of the proposed framework into practice. The validation process was conducted in two stages. The first stage consisted of pre-validation discussions with three researchers at different universities, who have a background in and knowledge of project management, facility management, and building technology, to optimise the interview questions. The second stage involved interviews with eighteen school managers as the end-users of the framework. The validation aimed to test the clarity and appropriateness of the proposed framework to offer guidance to stakeholders to provide an effective management for school property in NZ's state schools.

1.6 Terms and definitions

In NZ, Ministry of Education (MoE) uses the term "property management" to cover capital maintenance work such as refurbishment, extension, and reconstruction that serve to expand the building's functionality and service life; as well as day-to-day maintenance such as general cleaning, services, repairs, and redecoration that serve to prevent further deterioration or failure. In this research, the term "property and maintenance management" covers all property matters in

existing buildings and surrounding assets in NZ's state schools. In this research, PMMS stands for **P**roperty and **M**aintenance **M**anagement for state **S**chools in NZ.

The Ministry of Education is the owner of state schools and liaises with schools through its network of the Ministry property board (PO) and property advisors (PA). School boards of trustees (SC) have the responsibility to ensure their property is well managed and supports the delivery of education following the Ministry standards and guidelines. External consultants, including property planners (PP) and project managers (PM), are involved in school property projects to ensure the schools are being maintained in good physical condition so the life of school property assets is continuously preserved.

1.7 Outline of the thesis

The thesis comprises eight chapters and appendices as follows.

Chapter 1: Chapter 1 introduces the background, research justification, as well as research aims and objectives of the research and offers an overview of the research methodology. It also presents the terms and definitions used in this research and concludes with the introduction of the chapters of this thesis.

Chapter 2: This chapter presents a critical review of literature that provides background on and insight into the issues surrounding PMMS. The chapter begins with an introduction to maintenance management, followed by a discussion of the ISO 55000 for property and maintenance management and an explanation of the maturity model. An overview of property and maintenance management in NZ's state schools was also presented. The chapter ends with the requirements to conduct a preliminary study to refine the research objectives.

Chapter 3: This chapter describes the methodology employed in this research. It presents the research philosophies, research approaches, research designs and research methods used in the study. Furthermore, this chapter explains the research process in detail, including the use of interviews and questionnaire data. The procedure of selecting the sample, the data gathering techniques, the data analysis, and the data validity and reliability measures are also included in this chapter.

Chapter 4: This chapter presents the findings of the preliminary study and

main interviews. Details of the preliminary study and interviews, including planning, scheduling, and implementation, are described. Content and thematic analysis were conducted on the data to investigate current practices in school property management. The findings captures key processes, roles and responsibilities in school property and maintenance management. It also helps to propose the relationship between key stakeholders, which formed the basis for the questionnaire design in the next chapter.

Chapter 5: This chapter reports the findings from the questionnaire survey to identify the maturity level of roles and responsibilities in school property and maintenance management in NZ. The statistical analysis and the testing of the proposed model are presented. Consequently, improvement actions are also proposed for the higher level of maturity.

Chapter 6: This chapter discusses the new framework development and validation. The chapter describes the key elements of the framework, and outlines the findings from the preliminary study and questionnaires to refine the proposed framework. The comments and feedback from the school managers in the validation feature suggestions for potential implementation strategies for PMMS.

Chapter 7: This chapter presents a discussion of the significant research results, and then reviews them with reference to the relevant literature.

Chapter 8: This chapter features the conclusions and recommendations of this study. The summary of research findings, contribution to knowledge, recommendations, limitations of the research, and suggestions further research are also highlighted.

Appendices show documents used for data collection, including interview questions, questionnaires, and validation questions.

Chapter 2

Literature Review

2.1 Introduction

This chapter establishes the background to this study. Thus, the chapter starts reviewing definitions of asset management, asset management importance, stakeholders of asset management and asset management maturity. Subsequently, components of the International Standards ISO 55000 series for asset management are described to summarise requirements for asset management. In this section, different representations of asset management in built environments such as property management and maintenance management are also discussed. Subsequently, maturity model framework has been reviewed in consideration to help organisations evaluated and improve their asset management. The next section presents an overview of asset management in a school context with a focus on discussion of asset management in schools in NZ. Finally, the research questions that were developed from the literature review guide the next steps in this research study.

2.2 Asset management

2.2.1 Definitions and concepts

The term asset management (AM) is described and defined variously in different sources. The Royal Institution of Chartered Surveyors (2008) defines asset management as "a structured process that seeks to ensure best value for money from property assets in serving the strategic needs of public sector organisations". The

International Standard ISO 55000 has developed a well-considered definition for AM in clause 3.3.1: "the coordinated activity of an organisation to realise value from assets" (ISO 55000, 2014). The standard also provides a definition for assets that includes physical and non-physical assets that have potential or actual values to an organisation. The values involve a balancing of costs, risks, opportunities, and performance benefits. In considering definitions of AM, The Institute of Asset Management (2015) concludes that AM combines management, investment, finance and other activities applied to the management of assets and it is concerned with how to use assets to deliver value and achieve the organisation's business objectives.

In other words, an organisation controls and manages its assets to use them to support the organisation's objectives over their whole life through different stages. Different organisations have different approaches for AM to deliver the best total value. Organisations also differ with regard to how they define the term "activity". Generally speaking, an activity in AM can refer to a variety of applications such as plans, resources, and implementations. Relevant asset management subject areas summarised by ISO 55000 (2014) include, but are not limited to:

- Condition monitoring, inspection, maintenance
- Property management, facility management
- Life cycle costing, financial management

Hastings (2010) defines the first set of activities in AM as identifying what assets are needed according to inspection and condition monitoring results. Meanwhile, maintenance is defined as work on existing property assets and is the process of ensuring that assets and their services remain in a good condition, with a good appearance, and operate at optimum efficiency. Therefore, maintenance also includes inspection, condition monitoring, functional testing, repair, and individual asset replacement.

Property management and facility management are other aspects of AM. They have much in common regarding responsibilities for assets but activities for meeting those responsibilities is different (Manase, 2015). The core of property management activities involves valuation of property; acquisition and disposal of buildings; and provision of advice on property investment, while facility management is generally focused on end-users' needs and demands and is responsible for

health, safety and environment management (Balch, 1994). Along with the separated duties, there are common areas between property management and facility management such as maintenance, and information recording. However, different organisations have different definitions and concepts for managing their physical assets. Therefore, it is critical to provide insights into level of asset management, importance of asset management, stakeholders involved in asset management and practices of asset management in different countries determine gaps in research concerning the challenges in managing state school property, which will be addressed further in this thesis.

2.2.2 Asset management importance

Effective implementation of asset management enables the organisation to maximise the value of its assets by operating safely, optimising return on investment, reducing costs, managing risks, and meeting statutory obligations (The Institute of Asset Management, 2015). Any organisation, large or small, in any sector, public or private, needs to understand why asset management matters and the value AM brings to its own business. The key benefits of asset management stated in Clause 2.2 of ISO 55000 (2014) include, but are not limited to, the following:

- Improve financial performance, inform investment decisions, manage risk
- Improve services and outputs, improve efficiency and effectiveness
- Demonstrate social responsibility, demonstrate compliance
- Improve organisational sustainability, enhance reputation

The benefits of AM are proven in many industries, which allows organisations to optimise the whole life value of their managed assets portfolios (López et al., 2017). The first benefit of AM is managing the value of assets by balancing cost, risk, and performance. AM supports informed decision making for organisational sustainability by integrating long-term benefits with a shorter term activity of assets.

The second primary aim of an asset management system is to support the business of an organisation and to meet the expectations of its stakeholders (PAS 55, 2008*a*). Effective asset management allows organisations to improve efficiency and effectiveness by using standardised processes and competent people. AM systems also allow the collection of data and information that can be used to

improve understanding of asset performance, leading to improved services and outputs.

There is increasing recognition and acceptance that asset management is not only a technical subject but also have human factors within the organisational environment (Woodhouse, 2010). Effective asset management can have influences on staff and partners of organisations (Martin and Black, 2006), such as workforce motivation, loyalty, and staff and customer satisfaction. Organisations' reputation and image can be improved accordingly.

Some benefits listed above can be directly measured and quantified, such as costs, risks, and performance. Other benefits might be much more difficult to assess, for example social responsibility, compliance, and reputation. Effective AM system improves the health and safety of employees by reducing risks of accidents in operation; therefore, it can contribute to the reputation and social responsibility of the organisation (The Institute of Asset Management, 2015). While benefits related to finance and performance can be realised over the short term, sustainability, reputation, and social responsibility may only become evident after a long period of time. The undeniable importance of asset management has been proof that asset management is fundamental for operation of any organisation in any sector. However, priority of asset management in different organisations may vary. Therefore, it is critical to discuss how proper asset management including different levels of asset management in an organisation.

2.2.3 Levels of asset management

The ISO 55000 described a hierarchy of assets within an integrated management system, ranging from an individual asset to a system. Managing individual assets, such as physical equipment components, over their life cycles can be found at the bottom of the system. The concept of life cycle includes all activities of managing assets from the initial design through to disposal. Although individual assets can contribute value to an organisation, their value is usually generated in a system context, which is next level of the hierarchy (The Institute of Asset Management, 2015).

An asset system can be a transportation system, a power station, manufacturing plants, buildings, and airports. Managing asset systems is complex and requires careful consideration of the trade-off between system performance, costs, and risks over the assets' life cycles (PAS 55, 2008*b*). Conflicts may occur when

considering optimisation of individual assets' life cycles, and investment opportunities and performance of the whole system. A large organisation may also need to manage a diverse portfolio of asset systems. The focus of management at this level tends to turn towards return on investment, compliance, and sustainability (The Institute of Asset Management, 2015).

The highest level of AM is to support organisational objectives. Organisational objectives should be translated into asset management policy, strategy and objectives, asset management plans, and activities (PAS 55, 2008*b*). Senior managers are required to take account of the asset system's performance, opportunities, and constraints to establish, operate, and improve asset management within an organisation. It does not matter at what such level an asset management is identified, the AM should align with organisation's goals and strategic priorities. As asset management is an operation process involving different people from different departments, the most important factor is that all parts of the organisation should be aware their roles in each level of AM for the success of the asset management system.

2.2.4 Asset management stakeholders

Because asset management is concerned with the integration of multi-layered relationships in organisations, it is essential to define clear roles and responsibilities of people involved ensuring effective communication among the stakeholders. However, a rigid hierarchy of roles and responsibilities hardly fosters the kind of interdisciplinary problem solving required in asset management. Instead, one of the most important elements of asset management is that it is a team effort so collaboration among teams often include owners, managers, workers, suppliers, and consultants is central to its success (The Institute of Asset Management, 2015). Recent research suggests that organisational structure, engagement of the people, clarity of leadership, competence, and collaboration between stakeholders are critical in asset management (Manase, 2015; The Institute of Asset Management, 2015).

In all case, effective leadership has a critical role in achieving objectives of asset management. Edwards (2010) stated that leadership helps move AM from a functional view towards a more integrated view centred in their business. Top management should understand organisational business requirements for assets and allocate resources accordingly. Ali et al. (2008) argued that asset managers

should be functionally positioned at a strategic level which can assist the top management to make informed decisions. Top management also is responsible for integrating asset management in different departments in their organisation ensuring the success of AM at organisation level. The complexity of AM requires an interdisciplinary approach. It requires different individual specialists working in different professional areas such as developers, maintenance staff, IT, and project managers. Although these staff members work in their own disciplines, they must collaborate towards common outcomes, for example develop AM programmes and subsequently implement, evaluate, and improve them. Requirements for collaboration arise when participants have limited abilities to complete a given task, so combining their abilities helps complete the task more quickly and efficiently (Kalay, 2001).

It is widely accepted that collaboration improves productivity and performance in various industries and sectors (Akintoye and Main, 2007). However, bringing a group of participants to work together alone does not ensure the success of collaboration (Bouchlaghem, 2012). There exists conflicts because AM involves different people at multiple levels from different parts of organisations. These different participants will have different objectives, which might be often contradictory.

Asset management knowledge and competence are needed in many roles, not just by people labelled "Asset Manager" (Hastings, 2010). The knowledge and competence allow senior managers, for example Boards of Directors or Division Managers, make the informed decisions relating to asset capabilities, performance, opportunities, and budget constraints. At an operational level, maintenance and operation staff need to understand why, when, and how certain AM activities need to be done. Maintenance and operation workers can identify new and more effective ways of achieving AM benefits which may in turn have an influence on the strategic plans developed by top management (The Institute of Asset Management, 2015). In public sector, such as school buildings, asset management of the school portfolio usually require an extensive collaboration of key stakeholders due to large number of stakeholders such as government agencies, school boards, local communities and professionals (Earthman and Lemasters, 2013). Therefore, it is more important for the people involved to understand their roles, responsibilities and how to engage and collaborate various stakeholders to achieve strategic goals of AM.

2.2.5 Practice of asset management

2.2.5.1 Practice of asset management

AM is not a new discipline that has evolved over a number of decades from the industrial age (Edwards, 2010; Pilling, 2010). The term AM tends to be used in relation to physical assets and as such is relevant to all types of organisations, such as government, private, public, or not-for-profit. As such, AM theories and approaches are of interest on an international level.

In the UK, the term AM was first adopted in the 1980s by the oil and gas industry with the aim to manage oil platforms (The Institute of Asset Management, 2015). The term AM applied in the oil and gas industry focused on improving performance, safety, and productivity of the assets in consideration of their life cycle. The early 1980s can also be noticed as the point at which AM has been applied in the public sector in the UK (Harris, 2010). At that time, organisations focused on managing value and running costs of assets and monitoring the assets operation. The interest then moved to performance measurement and focusing on asset management planning, information management and prioritisation of budget (Manase, 2015).

At about the same time, in 1988, the US National Council on Public Works issued a guideline for taking inventory and monitoring conditions of public works in the transportation, water, and waste water industries (McDowell, 1988). The guideline enabled stakeholders to maintain their assets at a desired level of service at the lowest life cycle cost. the emergence of asset management has gained impetus from growing public and consumer scepticism and demands for greater accountability from the government bodies responsible for major capital investments in infrastructure and service provision, among others. In the USA this has led to a more asset-based approach to state financial reporting of facility condition and asset valuation. The poor state of infrastructure asset in the USA is considered to be a contributory factor towards the development of asset management.

As the demand for AM, the International standards have been developed by aligning approaches, principles, and disciplines on asset management to deliver greater value in developing and managing assets for organisations. The most notable developments have been issued in the publications listed below.

The Publicity Available Specification 55 series (PAS 55) was first published

in 2004 (re-issued in 2008) to set the standards for asset management. The development of the PAS 55 series has been led by the Institute of Asset Management (IAM), in collaboration with the British Standards Institution (BSI) and with the assistance of various co-operating organisations in the UK such as the Royal Institution of Chartered Surveyors, the University of Manchester, the University of Leeds, and organisations in different countries such as Canada, Australia, Southern African (PAS 55, 2008*b*). The PAS 55 series introduced the structure of an asset management system and its relationship to the organisational strategic plan and stakeholder expectations. The proposed AM system consists of AM policy, AM strategy, AM objectives, and AM plans.

In 2014, the ISO 55000 series of standards was launched by the International Organisation for Standardisation (ISO). The series prepared standards for the AM developing by common practices, which were used by a broad range of organisations in different countries (ISO 55000, 2014). The application of these standards provide an organisation with a guidelines to develop, direct, co-ordinate, and control asset management activities, and align those activities with the organisation's objectives. The requirements of the AM system described by ISO 55000 includes context of the organisation, leadership, planning, support, operation, performance evaluation, and improvement.

PAS 55 and ISO 55000 have been successfully adopted in a wide range of countries and sectors such as train lines, roads, electricity, and water (International Union of Railways, 2016; Lifetime Reality Solution, 2014). The standards are not a one-size-fits-all guideline, meaning that during the application process, organisation are likely to encounter a number of issues. PAS 55 and ISO 55000 mostly contain advice of what organisation should have, not how to build a successful AM system. Each organisation has to decide what activities from the AM model are required for them to achieve their organisational objectives (The Institute of Asset Management, 2015). These objectives are likely to reflect needs and expectations of its stakeholders such as owners, users, employees, and local communities. The next section will discuss requirements to be applied successfully ISO 55000 series in AM.

2.2.5.2 Asset management development in NZ

Manase (2015) states that a key success factor in asset management in NZ is

according to public sector-led initiatives including guideline development, training and asset management information systems development. The first public guideline concerned with AM was the "Total Asset Management Manual" published in 1993 by Transit New Zealand. The manual's objectives were to set out policies and procedures for managing the state highway network in a manner that meets Transit New Zealand's goals (Transit New Zealand, 1996). Transit NZ has introduced an extension of the Total Asset Management Manual in 2000. The new release entitled "State Highway Asset Management Manual" introduced a framework of methodologies and principles that are aimed at cost effective maintenance of assets (Transit New Zealand, 1996). Subsequently, the National Asset Management Steering (NAMS) group was established in 1995, comprising of both government and industry agencies, with the aim to promote infrastructure asset management practices, policies, and systems in NZ (The World Bank group, 2000).

The NAMS Group was formed to develop and promote asset management practices, policies and systems in New Zealand in a veriety of sectors such as transportation networks, energy supply systems, telecommunication networks, manufacturing plants, educational and health sector facilities, water utilities, and other community facilities. In 2010, NAMS has been identified as a NZ entity and has led the development of AM best practices within NZ (National Asset Management Support, 2018). NAMS provides manuals, and guidelines for AM worlwide. The newest edition of these guidelines and manuals is International Infrastructure Management Manual (IIMM) which has been driven by the updates to the ISO 55000 (National Asset Management Support, 2018). NAMS also offers a range of training services helping their customers know how to apply the standards for AM.

It can be seen that key influences on the development of asset management practices in public sectors in NZ were legal reform in accounting practices, requirements of transparent and long-term financial plan for public assets, and technological changes. Despite the development of AM in public sectors, previous studies have been revealed a number of problems still existed in AM in NZ such as focusing on cost alone, and lack of preparing for changes (Manase, 2015).

2.2.5.3 Understanding ISO 55000 for AM

The implementation of ISO 55000 system enables organisations to maximise the value of their assets by optimising the return on investment, reducing costs, managing risks, and improving sustainability, efficiency, and effectiveness. The principles of this series can be applied for asset management by any organisation. The ISO 55000 series includes three standards, namely ISO 55000: overview, principles, and terminology, ISO 55001: management systems-requirements, and ISO 55002: guidelines for the application of ISO 55001.

ISO 55000 provides a framework of requirements for managing the use of physical assets as illustrated in Figure 2.1. The requirements were categorised into six aspects of the asset management system of an organisation, including the organisational environment, planning processes, operational processes, support requirements, evaluation processes, and improvement processes. The ISO 55000 framework can be employed any organisation. However, it is challenging to adopt the series approach since the documents mostly contain guidelines on "what you must have", so that organisations need to determine the best way "how to achieve" the standards themselves. Organisations should consider requirements specified by the ISO 55000 framework to ensure that their system complies fully with the ISO 55000 standards. Understanding the requirements enable organisations to adopt the ISO 5000 standards to build a successfully asset management system. The requirements are listed below:

Organisational Environment

This part lists requirements for developing asset management objectives. All external and internal issues which affect asset management, such as regulations, laws, and the specific organisational context, are identified. The stakeholders' needs and expectations are identified and prioritised to understand what they expect from the asset management and to prevent conflicts between the stakeholders. Then, an asset management policy is developed to provide a set of principles for managing the assets. The scope of asset management covers all assets registered in the organisation's system and their detailed scope-of-work for usage and maintenance. The organisation's op management is responsible for developing the asset management objectives and for aligning it with the organisational goals and visions as well as for ensuring the success of the chosen asset management policy.

Support Elements

ISO 55000 series provide a list of factors that can facilitate the intended asset performance for the organisation. Thus, it is suggested that the organisation should identify all resources needed to deliver the asset management plan, for instance the budget, people, and equipment, and pinpoint any constraints between the organisation's capabilities and the resources needed. Among the resources, competence is one of critical support elements. Competence refers to the knowledge, skills, experience, and attitudes of people involved in the asset management activities. The organisation needs to identify its current competencies and any further training required. A communication plan covering all internal and external communications should be developed to ensure that the right information will be transferred to the right people at the right time. The organisation needs to decide which information needs to be collected, recorded, and managed to help the organisation analyse the current situation and make informed decisions.

Planning process

The organisation establishes its asset management plans to achieve its asset management objectives and describes the structures, roles, and responsibilities necessary to achieve the objectives. The plans need to specify how stakeholders' involvement in the asset management will be communicated and what resources will be required as well as the processes and methods needed to manage the assets. Identification and assessment of related risks and opportunities are also considered in this stage, and any planned changes should be assessed before the change is implemented.

Operation process

The organisation determines which activity will be outsourced and how to control the outsourcing process. For other activities implemented within the organisation, all criteria for the required processes including inputs, outputs, as well as control elements and mechanisms need to be established. The top management of the organisation considers which is the most effective delivery method to achieve the intended outcomes under the resources allocated.

Evaluation process and Improvement process

The purpose of monitoring and evaluating the performance of assets and the asset management is to ensure that the processes have been carried out as planned and the outcomes meet the stakeholders' expectations. The information collected in these processes aims to improve the performance of asset management.

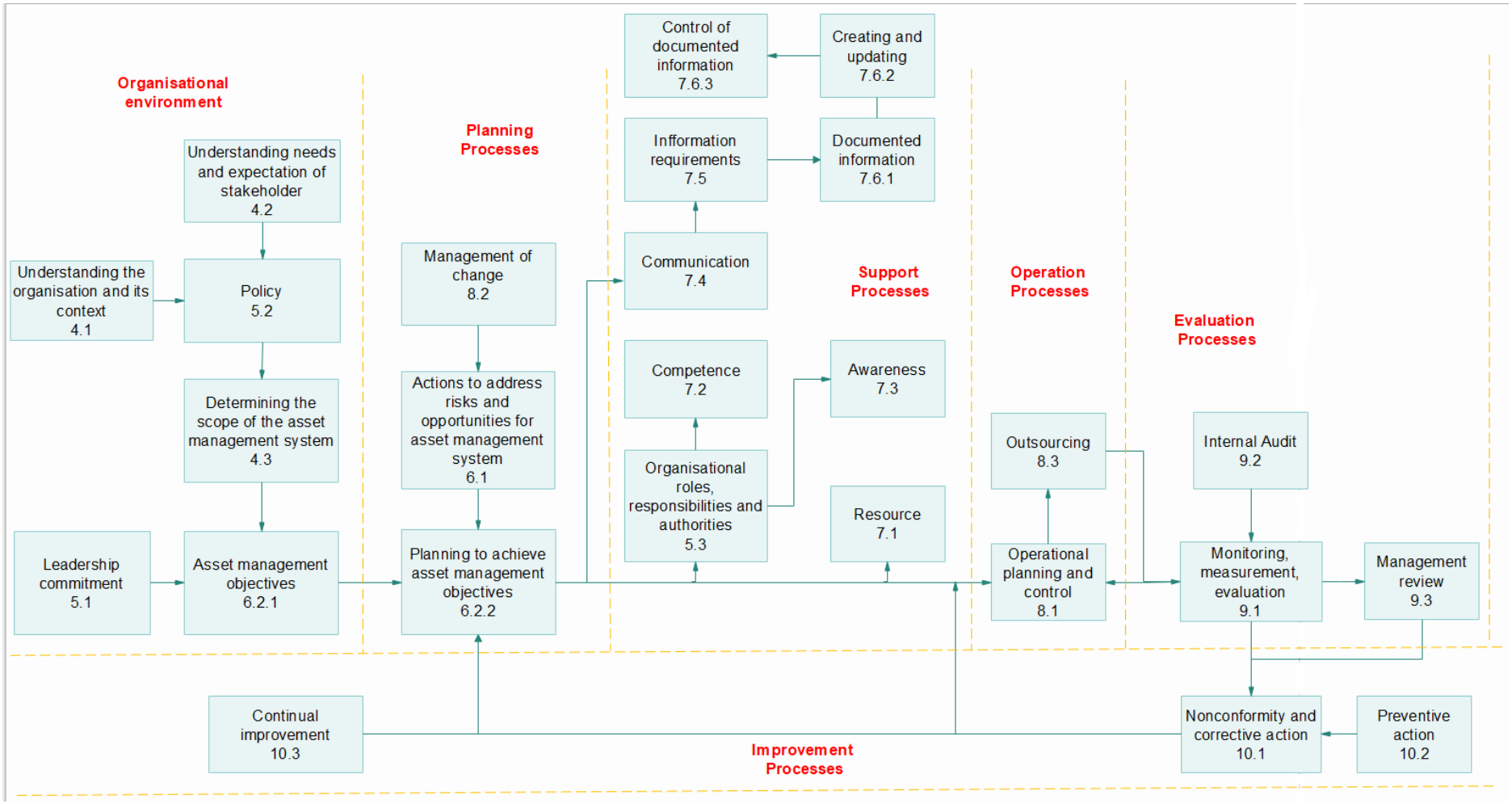


Figure 2.1: ISO 55000 requirements. Adapted from Lifetime Reality Solution (2014)

The organisation will determine what needs to be monitored and measured; when to monitoring and measuring and which methods and criteria to apply. The processes will generate lessons when incidents occur and how to minimise the effects. Preventive actions will be developed to avoid the same issues in the future. Further measures to improve the effectiveness of asset management are considered. There are different methods to evaluate a process and seek improvement such as maturity model.

The successful delivery of an asset management plans rely on its integration with other organisational business plans in both the development and delivery phases. The application of ISO 55000 in asset management varies across organisations as it provides a universal framework for managing the use of physical assets. It is advised that ISO 55000 contains requirements that any asset management system must have. However, ISO 55000 certification is not a guarantee of a good asset performance (Lifetime Reality Solution, 2014). Organisations that have adopted the ISO 55000 asset management methodology consider the outputs from their resourcing strategy, to achieve the asset management objectives, leadership and availability of competent people involved.

2.3 Building asset management

Built asset was defined by the British Standards Institute (2015) as a: "building, multiple buildings (a site or campus) or built infrastructure (such as roads, railways, or pipelines) that is the subject of a construction project". It suggests that management of built assets may include associated land or engineering systems that may comprise a portfolio or network of assets. Disciplines of asset management can be applied similarly to managing buildings and infrastructure. There are different terms and definitions of asset management for built assets such as property asset management relating to activities involved in managing land and buildings. Thus, managing built assets involves activities such as "refurbishments", "renovation", and "maintenance management". Similarly, asset management for built assets is the balancing of operations, maintenance, economics, and engineering in order to provide the most cost-effective and sustainable solutions over the whole life cycle of the built assets. In this section, property management and maintenance management discussed as the subject areas are relevant to managing NZ's state school properties.

2.3.1 Property and maintenance management

Property management is commonly considered as a part of asset management for built assets. While asset management is concerned with the management of the portfolio of assets as a whole, property management is focused more on the operational aspects of assets during their use phase as stated by Banfiled (2019). This argument is shared by Leaman (1992) who stated that property management focuses on the management at operation phase. Chen (2018) added that property management typically involves the management of property that is owned by another party or entity. This view is common in public sectors, such as hospitals, schools, or government buildings. Historically, the function of property management was not well-defined. Property projects have usually referred to major maintenance work such as renovation or refurbishment. Kyle et al. (2000) listed three primary functions of property management which are: 1) achieving the objectives of the property owners; 2) generating income for the owners; 3) preserving or increasing the value of the investment property. According to these functions, it is crucial that property management is to understand the owner's objectives and generate the greatest income of the investment property over its life cycle.

During the use phase of a property, maintenance is a continual process to help slow the property obsolescence, while renewal alternatives such as renovations or refurbishments may be considered when a property or its parts has failed to perform as designed or requires to be improved (Ali et al., 2009). Maintenance management contributes to the physical and financial well-being of an organisation (US Department of Education, 2003) by extending the life span of existing buildings and maximising their life cycle costing. Maintenance is an essential and critical part of asset management which helps to guide the physical performance of the asset and aims to optimise the management of the physical assets throughout their life cycle.

While maintenance management and property management are technically different, they both can be considered parts of asset management. Thus, both aim to enable organisations to optimise the whole life value of managing asset portfolios, yet property management and maintenance management adhere to different standards and specifications. This research study considers property management to go beyond maintenance management, but their functions overlap partly as presented in Figure 2.2. Although the aim of property management

and maintenance management can overlap, the scope of work of property and maintenance management should be clearly discussed.

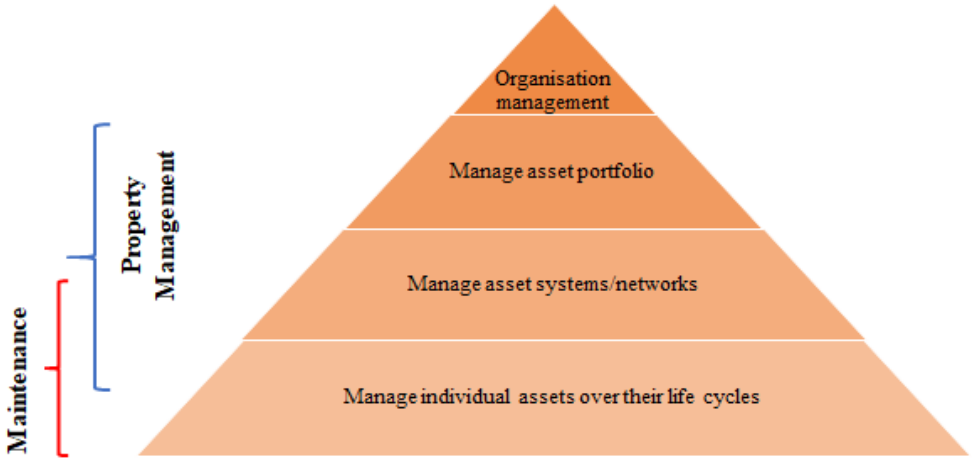


Figure 2.2: This research study's scope

2.3.2 Property management model

Property assets in the form of land and buildings play a critical role in the successful operation of any organisations. It is also discussed that the key difference between asset management and property management terms is the later managing assets on behalf of another party. Therefore, property management is considered a part of asset management, with similar tasks and objectives. As the results, the two terms are often used interchangeably in this thesis. Organisations can use requirements of ISO 55000 as discussed to develop their property management model. It may be necessary to modify these elements depending the nature of the organisations and their contexts. Although it is expected that management models will need to be changed over time, the models should illustrate (The Institute of Asset Management, 2015):

- the scope of asset management with its activities
- the interrelationships between activities
- the critical role for asset management to align with and deliver the goals of an organisation's strategic plan

The key elements and their relationships of asset management models are described and discussed in international models and standards such as PAS 55

(2008*b*), ISO 55000 (2014), and The Institute of Asset Management (2015). Figure 2.3 illustrates elements in an AM model as well as their relationships.

The model starts with the organisation and stakeholder context which decides the organisational plans and objectives. This suggests that when establishing or developing property management plans and objectives, organisations should consider their internal and external contexts. In addition to the organisation's context, stakeholder concerns and expectations are key to determining the property management objectives. The specific activities in property management will depend on the organisational purpose and context. For individuals, there is a different to develop details of activities in property management in school and railway sector. Regardless the purposes or context, it is important that everyone in an organisation understands how their activities fit and interact with other groups and actors within the organisation and with the overall objectives of the asset management.

Following the establishment of the internal and external objectives, the property management policy then will be developed to be consistent with the overall organisational objectives. The policy provides the framework which clearly states the principles to be applied in order to enable the asset management strategy and objectives to be implemented. Subsequently, property management plans specify detailed activities, resources, responsibilities, timescales, and risks for the achievement of the asset management objectives. During the development of property management plans, organisations should prioritise and optimise the activities in conjunction with the available resources. The plans should also address activities for all life cycle phases of the buildings and infrastructure.

In the implementation phase, organisations should establish, implement, and maintain processes and procedures to fulfil the property management plan. Delivery of the property management plan includes scheduling and management of resources. Specifically, schedules should align with operational objectives and avoid any system shutdowns or other access constraints. The effectiveness of the implementation is critically examined in the performance evaluation phase. Based on the results, needs are identified to improve property management performance. The performance can be measured using different indicators depending on the purpose of the evaluation. It is advised that the monitoring should be carried out in both proactive and reactive manners. The final element in Figure 2.4. is concerned with support elements. Different industry sectors can hold different

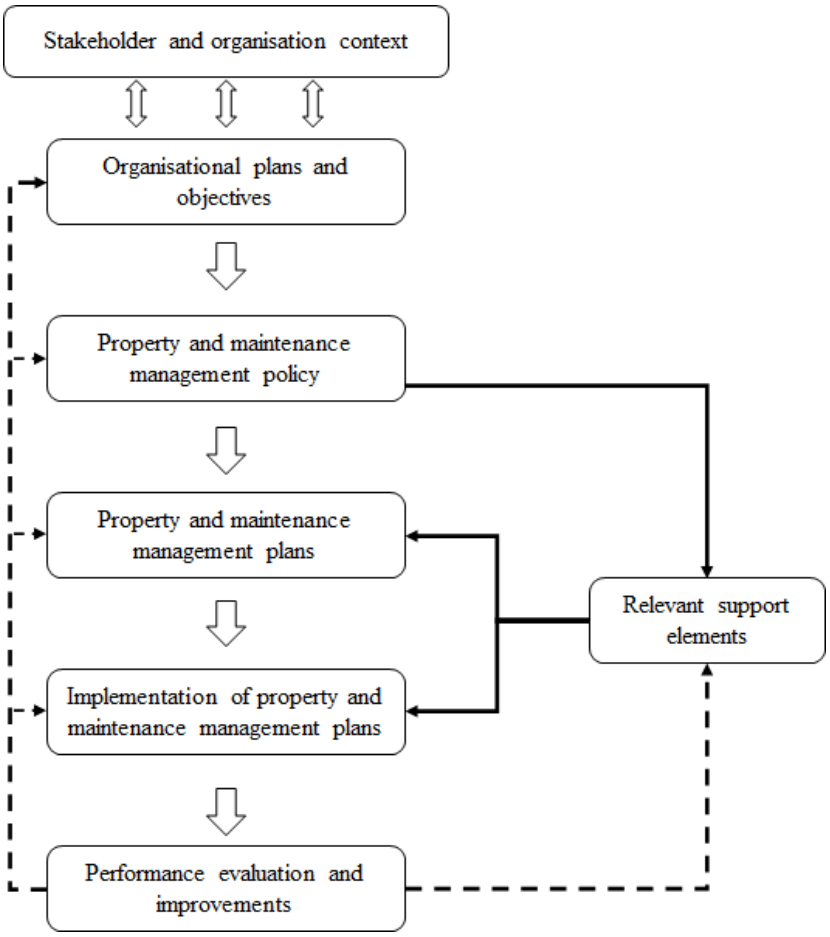


Figure 2.3: Property and Maintenance Management Model. Adapted from ISO 55000 (2014)

views about the support elements needed, or use different labels of the enablers.

Property management is common terms used in managing physical assets in public sectors such as government buildings, community parks or school buildings. In these case, property systems are used, managed and maintained by local councils or school boards on behalf of the owners who are state councils or central government. Therefore, stakeholders' engagement and expectations and organisation context is considered more important, which is the central point of this thesis.

2.3.3 Maintenance work for built assets

The British Standard Glossary defined maintenance as "the combination of all technical and administrative actions, including supervision actions, intended to

retain an item in, or restore it to, a state in which it can perform a required function" (British Standards Institution, 1984). In addition, maintenance management is critical part of managing existing buildings and infrastructure, by extending the life span of existing buildings and maximising their life cycle costing (Krstić and Marenjak, 2017). It is worth noting that maintenance management must fully align with business goals of organisations (Patiño-Rodriguez and Carazas, 2019). Over the past, stakeholders of building asset have required the outcomes of maintenance management to meet certain criteria (Queensland Government, 2017):

- re-instating physical condition to a specified standard
- preventing further deterioration or failure; restoring correct operation within specified parameters
- replacing components at the end of their useful/economic life with modern engineering equivalents
- making temporary repairs for immediate health, safety and security reasons
- mitigation of the consequences of a natural disaster and assessing buildings for maintenance requirements

Having established the maintenance objectives for a building portfolio, the next step is to consider how to achieve the objectives. It usually involves the strategy to determine what maintenance works need to be done, when it happens, what is the budget, and how the work can be done safety Royal Institution of Chartered Surveyors (2009). There are two common strategies in maintenance management: planned maintenance and unplanned maintenance, as illustrated in Figure 2.4.

Planned maintenance aims to prevent or decrease the number of major breakdowns/failures/damages to ensure a building/components/system continues at peak efficiency (British Standards Institution, 1984; Mirghani, 2001; Muyingo, 2009; New South Wales Heritage Office, 2004). Sub-categories of planned maintenance are time-based or scheduled and condition-based maintenance. **Scheduled maintenance** or preventive maintenance is carried out on a regular basis following manual instructions (British Standards Institution, 1984; Horner et al., 1997; Madureira et al., 2017; Queensland Government, 2017). It is carried out at a predetermined interval of time, number of operations, or mileage such as servicing boilers and heaters. Predictive and statutory maintenance can also be

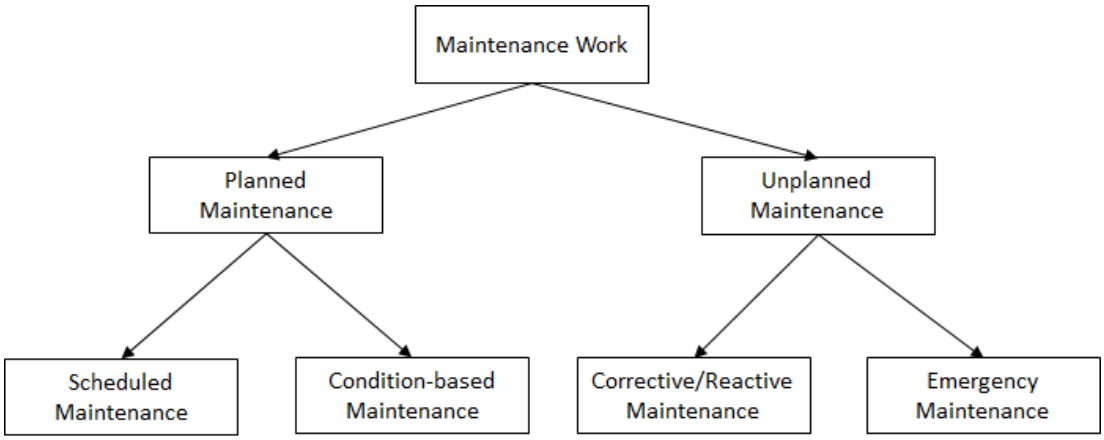


Figure 2.4: Type of maintenance

categorised as scheduled maintenance (Madureira et al., 2017; Ruparathna et al., 2018). **Condition-based** is initiated by the results of a condition assessment of an item from routine and continuous monitoring or other priorities such as health, safety, or sustainability (British Standards Institution, 1984; Queensland Government, 2017).

Although well-planned, maintenance work must always be ready to respond to an unexpected breakdown (Madureira et al., 2017). **Unplanned maintenance** consists of repair and replacement of elements due to the failure of preventive maintenance or natural wear and tear that sometimes is called **corrective/reactive maintenance** (EU Standard, 2009; Ruparathna et al., 2018). The planner should ensure that there is no conflict or duplication between corrective actions and planned operation. **Emergency maintenance**, as its name suggests, is work that must be delivered immediately due to health, safety,or security reasons or to avoid other serious consequences (British Standards Institution, 1984; New South Wales Heritage Office, 2004).

Corrective maintenance is the most favourable in the short term but conceals a high risk of consequential breakdown or damage. While the scheduled maintenance could lead to overspending, the condition-based strategy is generally considered the best for building maintenance (Kohler et al., 2012). The condition-based strategy uses regular inspection and assessment of the conditions to initiate maintenance action only when necessary. In other words, condition assessment collects information on existing buildings to make informed maintenance management decisions.

The selected strategy starts with conducting a condition assessment in order to evaluate the physical, functional and service aspects of building facilities and services. Without condition assessment information, one could not formulate maintenance activities and estimate costs. The use of condition assessment/inspection are typical means to collect relevant data for a comprehensive inventory (ISO 55000, 2014). It is suggested that the more regular a condition assessment is conducted, the better for the asset management. However, the cost involved is one of the challenges and redundant information are also wasted resources (Ahluwalia, 2008). Therefore, the assessment should be carried out in combination with other important activities such as during maintenance and operation (Dejaco et al., 2017). The frequency of condition assessments of a component depends on its critically to service delivery and complexity. The more critical and complex the component is, the more regularly a condition assessment should be conducted (Queensland Government, 2017).

It can be seen that maintenance management is the core activities and unable to be separated from property management. Results of condition assessment and maintenance outcomes are inputs for development of property management plans. While property management is usually at strategic level such as formulating the policies and allocating resources, maintenance management involves activities at operational level. Understanding the relationship between the strategic level and the operational level will contribute to the achievement of the organisation goals.

2.4 Asset management maturity

2.4.1 An overview of maturity model

It is crucial for any organisation to evaluate their processes and overall maturity levels, leading to a road map for progressive development. "Maturity model" is a conceptual framework, initially used in the software engineering industry, that describes current maturity levels of an organisation's services or specific tasks whereby organisations can develop improvement actions to increase its maturity levels (Crawford, 2015; Project Management Institute, 2013). Not all organisations need to reach the highest level of the maturity model as this level may require significant additional resources and results in substantial changes to the organisation. Appropriateness of the maturity improvement process should be

focused on rather than the absolute score of the maturity level (Jia et al., 2011).

Several maturity models have been developed to guide organisations in the assessment of their current state in the area of interest by comparing the best practices and the quality standards of the organisation to others (Albliwi et al., 2014). Organisations can develop their maturity models for their own purposes and contexts. The models are usually adapted from Capability Maturity Model (CMM) for assessing process maturity (Albliwi et al., 2014) or from the Organisational Project Management Maturity Model (OPM3) for assessing organisational capabilities (Silva et al., 2019).

While CMM focuses on addressing process issues within an organisation, OPM3 uses bench-marking to improve the competitiveness of organisations. CMM has been designed to measure maturity levels of processes or activities of service providers (Pourikas and Fitsilis, 2010). Each process is described by its inputs and expected outputs. CMM focuses on the assessment of individual processes or activities for improving these processes, leading to greater maturity or optimisation of the whole process. Therefore, CMM is preferable to assess and where needed, improve the efficiency of asset management including property and maintenance management (Chemweno et al., 2015; Macchi and Fumagalli, 2013).

2.4.2 Capability Maturity Model: two representations

There are two alternative representations in the CMM: Staged Representation (SR) and Continuous Representation (CR). SR includes 5 maturity levels and each maturity level constitutes a predefined set of process areas and generic goals as shown in Figure 2.5. Thus, the five maturity levels are: Level 1: Initial, Level 2: Managed, Level 3: Defined, Level 4: Quantitative Managed, and Level 5: Optimising. It also presents a predefined road map for improvement for every maturity level, indicating what areas to focus on to improve the whole company (Macchi et al., 2011). Once a maturity level is reached, the organisation is able to move to the next higher level following the predefined path. There is only one way for the organisation to develop its full potential. The measurement scales of SR are defined as below (CMMI Product Team, 2001):

- Level 1: The process is weakly controlled or not controlled at all.
- Level 2: The process is partially planned; performance analysis is mostly dependent on individual practitioners' experience and competences; process

management is weak because of deficiencies in the organisational or in the technical systems.

- Level 3: The process is planned; semi-quantitative analyses are done periodically to define good practices/management procedures; process management depends on some specific constraints related to organisational responsibility or technical systems.
- Level 4: Process performance is measured, and causes of special variations are detected; quantitative analyses are conducted, a good balance is reached between the quantitative and qualitative analysis; process management is fulfilled thanks to organisational responsibilities and fully functional technical systems.
- Level 5: Process is managed by ensuring continuous improvement; causes of defects and problems in the processes are identified; taking actions in order to prevent problems from occurring in the future.

In contrast, the road map of CR is more flexible. CR defines six capability levels to represent a measure assigned to individual process areas as shown in Figure 2.6. The six levels are: Level 0: Incomplete, Level 1: Performed, Level 2: Managed, Level 3: Defined, Level 4: Quantitative Managed, and Level 5: Optimising Process. Every process area can be measured separately and has a different capability level. Organisations can select which processes or activities need to be evaluated and then improved. Continuous representation (CR) focuses on the organisation's capability levels to perform, control, and improve its performance in selected process areas. These levels allow the organisation to improve processes associated with the process areas. The organisation's progress will be recorded and evaluated accordingly (CMMI Product Team, 2001). The measurement scales of CR are defined as below (CMMI Product Team, 2001):

- Level 0: A process that is considered incomplete and does not implement all of the capability level 1 specific and generic practices.
- Level 1: A performed process is a process that is expected to perform all of the capability level 1 specific and generic practices. Performance may not be stable and may not meet specific objectives, such as quality, cost, and schedule, but useful work can be done.

- Level 2: A managed process is planned, performed, monitored, and controlled for individual projects, groups, or stand alone processes to achieve a given purpose. Managing the process achieves both the model objectives for the process as well as other objectives, such as cost, schedule, and quality.
- Level 3: A defined process is a managed process that is based on the organization's set of standard processes. Deviations beyond those allowed by the tailoring guidelines are documented, justified, reviewed, and approved.
- Level 4: A quantitatively managed process is a defined process that is controlled using statistical and other quantitative techniques. Product quality, service quality, process performance, and other business objectives are understood in statistical terms and are controlled throughout the life cycle.
- Level 5: An optimising process is a quantitatively managed process that is improved based on an understanding of the common causes of process variation inherent in the process. An optimising process focuses on continually improving process performance through both incremental and innovative improvements.

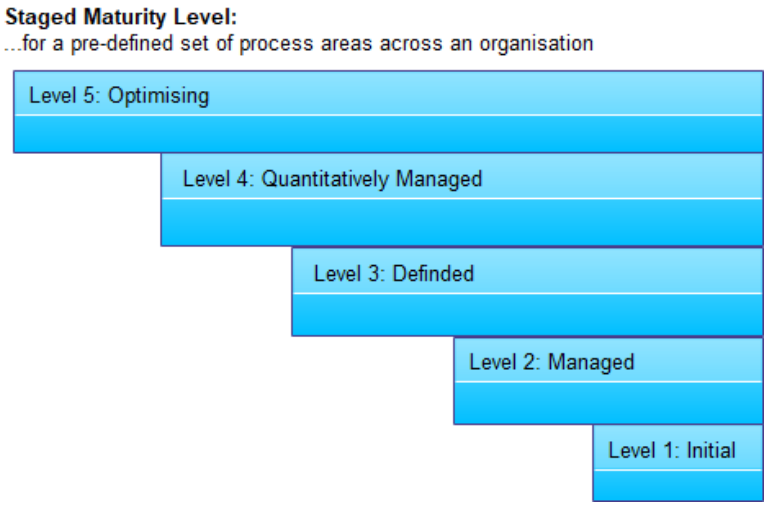


Figure 2.5: Staged representation. Adapted from CMMI Product Team (2001).

Macchi and Fumagalli (2013) summarised that SR is more rigid as it has only one predefined path which must be followed to reach a predefined series of goals to step up to the upper level. Meanwhile, CR offers a road-mapping flexibility as its maturity can be analysed by referring to each single process area (PA). Therefore,

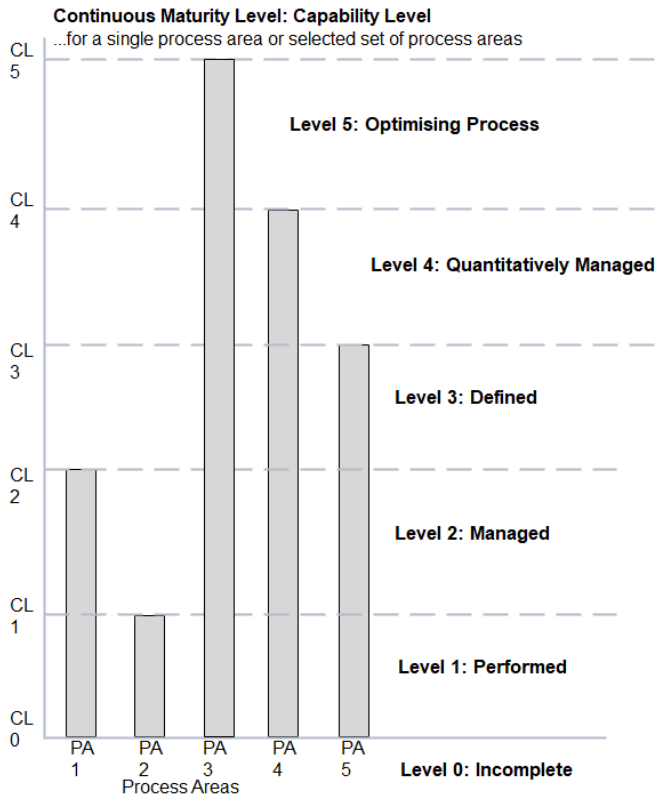


Figure 2.6: Continuous representation. Adapted from CMMI Product Team (2001).

CR has more advantage for prioritising process improvements and aligning them with the organisation's business objectives. In public sectors, the budget for the improvement is limited, so using CR enables the budget to be allocated more effectively and efficiently by pinpointing the specific areas that need it the most.

Although the two representations are clearly defined, various models have been developed by individual organisations as in-house maturity assessment tools, the models are widely different due to difference in several aspects such as organisational structure, cultures, or business context (Chemweno et al., 2015). Characteristics of organisational context affect definitions of what reaching a "competent" or "excellent" level entails. The features that would be recognised as "Excellent" in one sector may not be the same definition in another. Therefore, developing and applying these models to different organisations may not be straightforward.

2.4.3 Maturity model in AM

In the field of asset management, many organisations are using ISO 55000:2014 standards to assess their asset management system (Sharp, 2013; The Institute of Asset Management, 2014). Results of the assessment help identify performance gaps between the organisation's asset management performance and the good/best practice nationally and internationally to guide them on their maturity path. The Institute of Asset Management (2014) introduced a self-assessment methodology (SAM) for use with ISO 55000. SAM provides a question set with 39 questions covering each of the 27 clauses of ISO 55000. There is no order of importance applied and each question carries same weight. The maturity answers compare the maturity level of asset management of the organisation against the ISO 55000 standards. The average score for each element/clause is marked on a radar chart which can then be compared to the maturity scale to identify significant deficiencies or weaknesses in the asset management of the organisation.

Figure 2.7 shows the maturity scale used for the conformance with ISO 55000 standards. As illustrated, the ISO 55000 standards have been captured in 6 levels of maturity, ranging from level 0 to level 5. In the figure, level 4 and 5 have been combined and are referred to as "beyond". This maturity scale also provides an indication of the characteristics those organisations that achieved the requirements of ISO 55000 are likely to have. Table 2.1 displays the different characteristics of each level when carrying out the ISO 55000 assessment. It is also recommend that in order to achieve a particular maturity level, organisations should satisfy all requirements of the previous levels.

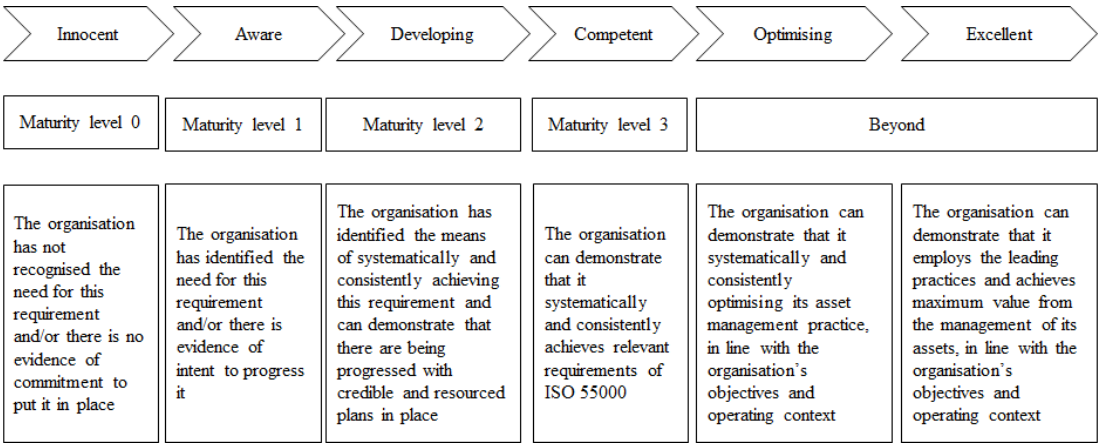


Figure 2.7: Maturity scale for ISO 55000:2014. Adapted from The Institute of Asset Management (2014).

Table 2.1: Characteristics of maturity scale based on ISO 55000:2014 . Source: The Institute of Asset Management (2014).

Scale	**Characteristics**
Level 0: Innocent	
Level 1: Awareness	Proposals are under development and some requirements may be in place. Processes are poorly controlled, reactive, and performance is unpredictable.
Level 2: Developing	Processes are planned, documented (where necessary), applied, and controlled at a local level or within functional departments; often in a reactive mode but could achieve expected results on a repeatable basis. The processes are insufficiently integrated, with limited consistency or coordination across the organisation.
Level 3: Applying	This involves a formal documented asset management system embedded within the organisation. The performance of the asset management system elements is measured, reviewed, and continually improved to achieve the asset management objectives.
Level 4: Optimising	Monitoring and quantification of performance and resolution of trade-offs between competing goals in an agile decision-making framework. Innovation is a way of life, continual improvement can be widely demonstrated with evidence of results, benchmarking is employed to identify further improvement opportunities, and the management system is even further integrated and effective.
Level 5: Excellence	This is a dynamic and context-sensitive state, so the evidence must include demonstration of awareness of benchmarking positions against similar best in class organisations and that, in both asset management practices and asset management results (value realisation), there are no known improvements that have not already been implemented.

The SAM and maturity scale have been applied in many organisations in different sectors in order to develop a transformation road map for their asset management. Although the assessment scale might be adjusted to fit particular context of the organisation, the assessment framework remains consistent with ISO 55000 standards. Australia Asset Management Council (2017) has developed an asset management maturity assessment tool for public assets that were built in accordance with the requirements of the ISO 55000 standards. The assessment

model has three different options, namely light assessment, light assessment with benchmarking, and full assessment. The light assessment scores only assess the organisation asset management maturity level for 10 core system elements, while the second option benchmarks the organisation maturity level to others in the same industry or other industries where possible. The full assessment report will highlight the strengths and opportunities of the organisation in the development of its asset management. Asset Insight Management Ltd, which provides asset management coaching to organisations, developed a six-tiered maturity scale, aligned ith ISO 55000 requirements, which helps organisations to benchmark their current maturity level and develop targets to reach the next level of maturity (Asset Insight Management, 2020).

In NZ, the Treasury Government developed an asset management maturity assessment based on ISO 55000 which helps reveal the extent of differences between current and target levels of asset management maturity in each agency. The assessment model uses a five-level scale with scores from 0 to 100 for each asset management section (The Treasury, 2017). The overall scores for each asset portfolio are calculated across 16 questions divided into three sections: understanding and defining requirements, life cycle decision making, and asset management enablers. The agencies have to answer these questions, provide evidence for these answers and present an action plan for development. The assessment model is advised to be used for typical assets such as transportation networks (roads, rail, ports); energy supply systems (gas/electricity); parks and recreation facilities; water utilities; property networks such as educational, health, commercial property, and defence; telecommunication networks; and information technology and systems. In terms of improvement recommendations, agencies are required to focus on those aspects of practice that offer the best value to them.

It has been demonstrated that the maturity model framework has been widely used for evaluating the maturity of asset management in organisations. However, each sector or individual organisation has developed different maturity models regarding their purposes and use. Regardless of the differences, a maturity model usually consists of the following components (Chemweno et al., 2015; Oliveira et al., 2012; Tarhan et al., 2016; The Institute of Asset Management, 2014; UMS Group, 2013):

- Number of levels (usually 4, 5 or 6 levels) and label of each level
- Number of process areas for assessment

- List of indicators/activities at each process area
- Definition of each level including characteristics of each indicator/activity as performed at each maturity level

Organisations can either use Staged Representation (SR) to draw a path for improvement for the whole process/system, or Continuous Representation (CR) instead as it analyses its maturity with reference to each individual process area (Meng et al., 2011). The key idea of CR approach is that the improvement can only happen by instigating changes in specific areas of the process so that change occurs step by step, rather than through holistic changes.

2.5 Asset management for schools

2.5.1 Research subjects on AM for schools

As the data in Figure 2.8 shows, evidence suggests that the quality of school buildings can impact educational outcomes. Therefore, it is critical that school buildings are well maintained to provide a comfortable physical environment supporting teaching and learning activities (Abdelhamid et al., 2013; Trachte and De Herde, 2015; Vieira and Cardoso, 2006). School buildings are not only supposed to provide a pleasant, safe, and free-hazard environment for staff and students, but they are also a clearly visible presentation of the education system and their state may affect the public's confidence in the quality of education offered (Ministry of Education, 2011). Moreover, failure to maintain school buildings may lead to budgetary reductions of future investment in the public education system (US Department of Education, 2003).

School managers, practitioners, authorities and researchers have become aware of the links between building standards and learning outcomes. As a result, academic and practical interest in asset management for schools has increased substantially. Some of the large research questions are:

- Does school design/facility affect academic outcome, including what are high performance design features? The research findings provide lessons learned from design and construction processes for high performance learning environment (Ali et al., 2013; Schneider, 2002; Tanner, 2009).

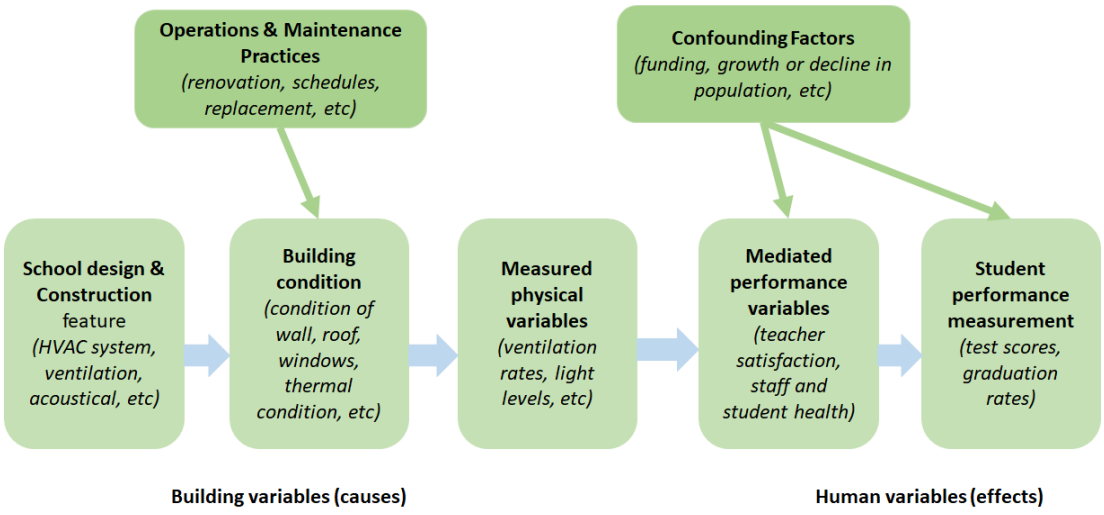


Figure 2.8: Building variables for education. Adapted from McGraw Hill Research Foundation (2012).

- How to measure building performance and, more importantly, what to measure? Many research studies focus on solutions to improve building environment such as daylighting, ventilation, thermal comfort, and acoustic (Figueiro and Rea, 2010; Heschong and Mahone, 2003; Wang et al., 2016; Wargocki and Wyon, 2013).
- What are cost-optimal measures for school buildings? The research in this field addresses operational problems, such as inefficient energy consumption, and propose strategies for sustainable alternatives for existing school buildings (Congedo et al., 2016; Dalla Mora et al., 2017; de Santoli et al., 2014; Österreicher and Geissler, 2016).

Researchers have become increasingly engaged in these questions. Thus, studies in this field so far have focused on technical issues of particular cases, while only few investigations have attempted to examine larger units, for example the whole system of state schools. Vieira and Cardoso (2006) conducted a study on secondary school buildings in Portugal. However, the research only listed building characteristics and securities, both inside and in surrounding areas of the school, and identified areas for improvements in the maintenance management. More recently, Is'haq et al. (2013) introduced a framework to assess the quality of the property management service in public educational buildings in Nigeria. The research focused on the evaluation of the users' expectations and perceptions

of asset management in their offices. Only those gaps that indicate a low quality of service in the educational buildings were addressed, but solutions for the gaps were not offered. One improved framework was produced by Abdelhamid et al. (2013) which introduced a score system to assess the asset management strategies and practices in educational buildings in Egypt. The research focused on assessing four sections of asset management, including data and information systems, strategic asset planning, processes and practices, and people and organisation. Key areas for the improvements were proposed with 12 priorities such as training, roles and responsibilities, data collection, assessment, and condition monitoring. Previous studies seldom investigate about how the relationships between key stakeholders, especially between strategic level and the operational level.

2.5.2 Asset management for NZ's state schools

2.5.2.1 State school system in NZ

There are different types of schools in NZ's state school system. According to the Ministry of Education's category, there are six types of school: primary school, full primary school, secondary school, composite schools, intermediate schools and special schools. Primary schools cover the first six years of schooling, while full primary schools cover years 1 to 8. Intermediate schools, where they exist, cover years 7 and 8. Secondary schools cover years 9 to 13. Composite schools are schools that incorporate a range of year groups that transcend the normally accepted year group boundaries between primary and secondary schools. In this research, primary schools are schools that host between year 1 to year 8, while secondary school covers years 9 to year 13.

The state school property managed by the Ministry of Education consists of 2,100 schools with over 30,000 buildings and 35,000 classrooms, comprising of approximately 8000 hectares of land overall (Ministry of Education, 2020). Among these schools, 75% of which are primary schools, 12% are secondary schools, and 13% account for other sectors. Around 800 million capital and 170 million (NZD) operating expenses are spent each year on existing schools to ensure they are in good condition (Ministry of Education, 2017). Regarding the school size, statistics indicate that the average roll size of a primary school is 236 students, while

this number of a secondary school is 845. The median school roll across the portfolio is around 200 students. Around a quarter of schools have rolls under 100 Ministry of Education (2020).

Approximately 80% of school buildings in were built in the period 1950 – 1999, and 62% of all school buildings are older than 40 years, with over one thirds are older than 50 years (Ministry of Education, 2017). The wide range of building ages, as presented in Figure 2.9, and complexity of space functionality require school stakeholders to fully understand the PMMS, including planning, implementing, and monitoring, to optimise the decision-making process for maintenance, refurbishment, renovation, and demolition of the buildings. The MoE uses the term property management to refer to the management of school assets including buildings' structures, building fabric, building services (water, electrical, heating, and ventilation systems), and the schools' infrastructure such as fence, gate, swimming pool, playground, garden, drainage, and pathway.

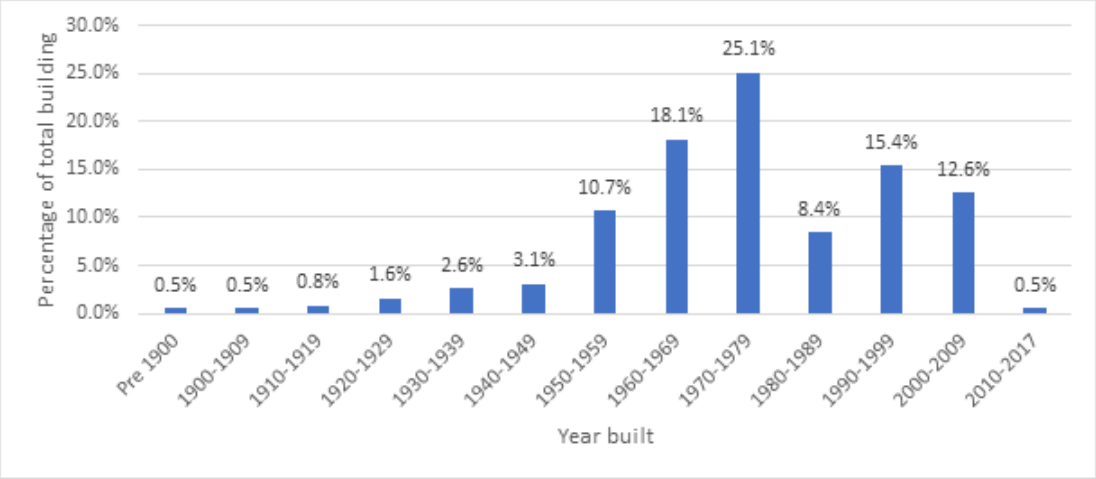


Figure 2.9: Age distribution of school buildings. Source: Ministry of Education (2017).

2.5.2.2 Property and maintenance management for NZ's state schools

Each state school in NZ is required to develop a short-term and long-term property plan, called the 10-Year Property Plan (10YPP), to identify capital projects and maintenance work to ensure that the school property is fit for purpose. All property projects and maintenance work in state schools are covered by one of three funding sources from the MoE: 5-year agreement funding (5YA), property

maintenance grants (PMG), and operational grants (OPG). Figure 2.10 shows the 10YPP process and role division between the school boards and the Ministry. Once the 10YPP is approved, 5YA funding will be signed off every five years for schools to implement the identified projects.

Regarding short-term maintenance, PMG is funded annually for schools to spend on painting, minor replacement, minor repairing, and minor ground and site maintenance such as replacing a small section of a broken water pipe or minor repairs to floor covering. PMG is calculated based on the size of the school such as the total areas of buildings. The operational grant covers day-to-day expenses such as cleaning, rubbish disposal, pool chemicals, grass cutting, utilities (heat, light, water), maintenance of furniture and equipment, and repairing damage caused by vandalism. The operational grant is calculated based on the number of students enrolled in the schools each year.

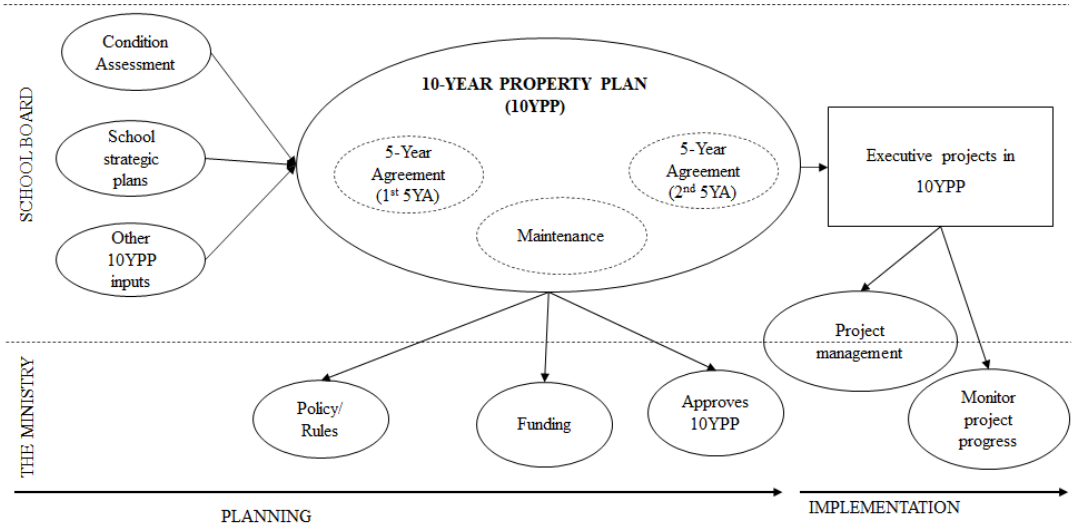


Figure 2.10: 10YPP process. Source: Ministry of Education (2017)

School property management in NZ takes place at both a school level and a national level by managing two different types of property projects, as shown in Figure 2.11. At national level, the Ministry Team will manage the projects for major development, and national programme such as earthquake and weather-tightness. The team has full responsibility for the projects from the beginning such as design, procurement, and construction. The constructed buildings/facilities will be handed over to schools to operate and maintain after completion.

Due to the national level projects are implemented in particular schools, this research only focuses on school-led projects which cover property projects (5YA) and maintenance work (PMG, OPG). The following terms and definitions of the projects were extracted from the internal sources of the MoE (Ministry of Education, 2015) and are illustrated in Figure 2.11.

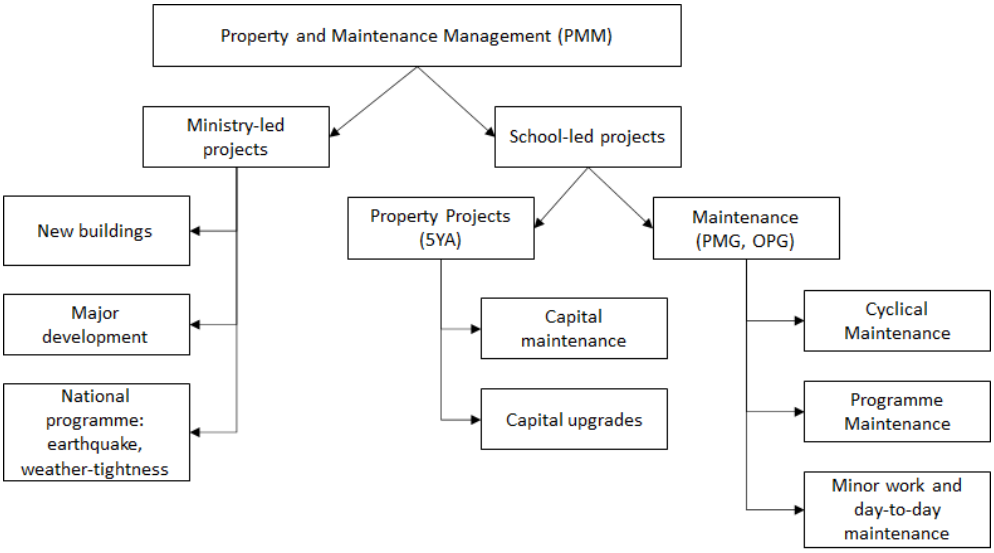


Figure 2.11: PMMS work categorisation

Capital maintenance: work to replace or undertake major maintenance of a value of equal to or greater than 5,000 NZD to an existing property or element to preserve the life of that asset to ensure it can continue to be used for its existing purpose, for example, replacement of carpets, roof maintenance, or services such as the installation of heat pumps.

Capital Upgrades: work to upgrade existing property, where a new asset is created or an existing asset is updated in the Ministry's balance sheet. The capital work can be refurbishments, renovations or the building of a block. The 5YA is the agreement by the Ministry to provide schools with funding for capital maintenance and capital upgrades.

Maintenance: Cyclical maintenance: regular maintenance work like internal and external painting or surface protection for existing buildings and structures. Programme maintenance: painting under a long-term contract, usually an annual contract. Cyclical and programme maintenance as well as minor work and ground maintenance are covered by PMG. Minor work is defined as minor repair/replacement that costs less than 5,000 NZD.

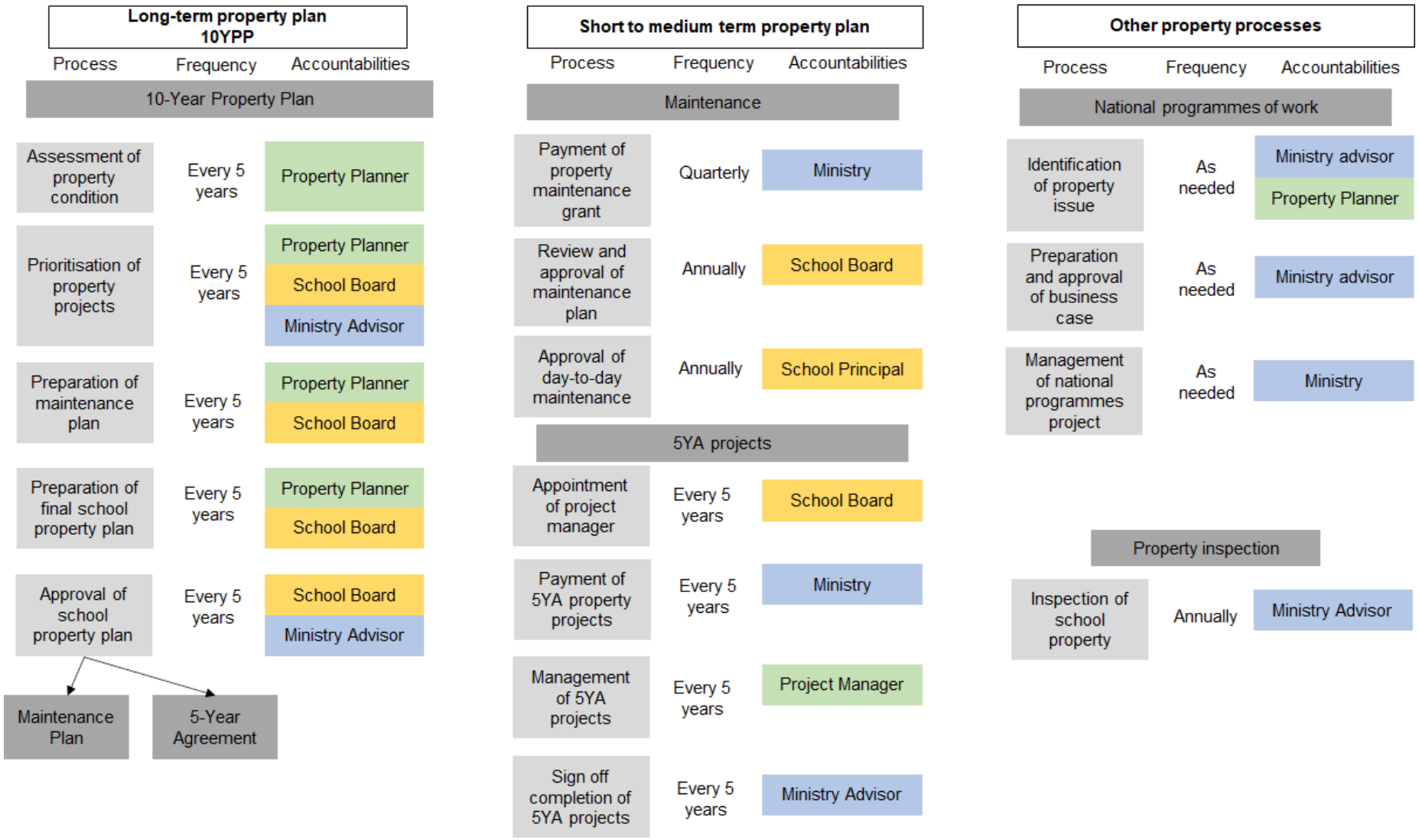


Figure 2.12: Current processes in PMMS. Adapted from Controller and Auditor (2017)

Property and maintenance management for state schools in NZ involves the multi-layered relationship among schools' stakeholders, which include the MoE's property board (PO), MoE's regional advisors (PA), the school's board of trustees (SC), external consultants (project managers (PM) and property planners (PP)). Figure 2.12 illustrates the processes and responsibilities of the people involved in PMMS. The diagram illustrates three different strategies in the PMMS in three columns: long-term property plan, short to medium term property plan and other property processes. In each column, processes, frequency of process, and accountabilities are presented. There are some processes implemented by one party, while others require collaboration of different parties. In the current process, schools employ external consultants to deliver a specific tasks, with guidance and supports of property advisors. The more understanding of the how people involved working together, the more opportunities for accomplishing common goals. However, there is no such information about the ways to better manage the school properties.

2.6 Overview of previous studies and development of research questions

It is concluded that asset management is essential to operation of any organisation regardless its differences terms and definitions. Many frameworks have been developed for asset management in various sectors in different countries. ISO 55000 series provided an international standards for the development of a asset management framework. However, the series mostly contain guidelines on "what you must have", so that organisations need to determine the best way "how to achieve" the standards themselves. Section 2.2.4 summaries that asset management is concerned with the integration of multi-layered relationships in organisations. There is a suggestion to study the relationship between strategic level and operational level and clearly define roles and responsibilities of people involved. The second part of this chapter discussed maturity models for asset management assessment. Different representations, scales, and frameworks have been considered to help decision-makers evaluate current practices and propose improvements for their asset management system if necessary.

The review also presented property and maintenance management as a part

of asset management for built assets in schools. Previous studies proof the impacts of school buildings on teaching and learning activities and it is important to ensure the best value of money for investments in school buildings. Most of the previous study centered on technical aspects of managing existing school buildings. There is no further information to explain how effectiveness of the property and maintenance management at schools and how the relationships between key stakeholders involved are not known. In NZ's state schools, although school property strategy is clearly defined but their is also question on roles and responsibilities in PMMS and relationships between these processes have not been considered.

The reviewed literature has provided insights around asset management, focusing on property and maintenance management for schools, and also research methods. The research questions have been developed to fill the gaps in the literature. Due to the various stakeholders involved in PMMS and they are based in different organisations and having a great variety of interests and abilities, it is essential to understand their roles and responsibilities. Thus, the first question is *"what are roles and responsibilities and how they are organised in property and maintenance management for NZ's state schools"*. Furthermore, it is critical to investigate the maturity level of the roles and responsibilities to explore challenges existing in PMMS and the relationships of people involved. The second and third questions are followed: *"what is maturity level of the responsibilities"*, and *"what are relationships between people involved"*. Answers of the first three questions contribute to achieve the primary aim of this research by better understanding of practices and challenges in PMMS. The last question is *"how to improve the property and maintenance management in NZ's state schools"*. It is suggested to develop a framework using ISO 55000 standards to offer a guidance to the stakeholders in their effort to provide better property and maintenance management and at the same time improve their collaboration.

2.7 Summary

The aim of this chapter was to investigate an insights of property and maintenance management in the context of asset management with specific reference to state schools in NZ. The importance of asset management, stakeholders involved in asset management and maturity models for asset management have been reviewed

to provide a background for this research. The review established the research questions with the aim to improve property and maintenance management for NZ's state schools. Due to the lack of research on property and maintenance management in NZ's state schools, there is a need to conduct a preliminary study to refine the research objectives. Research methodologies and methods to answer the research questions are discussed in Chapter 3.

Chapter 3

Research Methodology

3.1 Introduction

This chapter outlines the research methodology and methods that were used to achieve the research aim which was identify to develop an effective property and maintenance management framework for state schools in NZ. Therefore, the chapter begins with a general introduction to the philosophical perspectives of research that guided this research, and then describes the widely used research approaches in this area. Finally, the selection of the approach adopted for this research study is discussed. The chapter presents the research design and method, the development of the sample selection, the data collection procedures, methods employed in the data analyses, and the model validations.

3.2 Research philosophy

Saunders et al. (2016) stated that understanding the philosophical stance of research should be the first step in research development. Creswell (2017) argued that philosophical ideas influence the practice of research and need to be identified. In short, a research philosophy is belief of researchers about the appropriate methods in which research data should be collected, analysed and generated. Researchers have referred to as *"ontology"* and *"epistemology"* to describe the philosophical orientation in a research (Bryman and Bell, 2011; Saunders et al., 2016). Ontology is concerned with the existence of knowledge and the nature of knowledge, and describes what knowledge is (Fellows and Liu, 2015). Ontology is commonly categorised into *objectivism* and *constructivism*. Epistemology

refers to the nature of human knowledge and how researchers know the reality. Epistemology is divided into *positivism* and *interpretivism*.

In the context of this research, the final outcome should generalise a framework to be used in PMMS. The process of designing and developing the framework should also be considered, as validating the model is as important as establishing it. The researcher believes that PMMS is affected by the interactions between stakeholders of the process and that those relationships influence the goals of the research. As Creswell (2017) discussed in his book, positivism assumptions represent the traditional form of research, namely that a researcher begins with a theory, collects data to test, and refines a theory to develop the knowledge. Bryman and Bell (2011) agreed with this view that positivism describes social phenomena in a similar way to the natural sciences. Positivism is dependent on believing that only observation would yield valid knowledge. Interpretivism, on the other hand, is the belief that human interaction and reaction are fundamental to the understanding of our social reality rather than the natural science methods (Bryman and Bell, 2011; Fellows and Liu, 2015). According to Bryman and Bell (2011), objectivism is the belief that the existence of social phenomena and their meanings is independent of human observation, while constructivism is the idea that reality is accomplished by social actors. Based on the research questions, the researcher will use the ontological constructivism as the research focuses on understanding the reality of things and requires an understanding of social factors affecting the hierarchy of maintenance processes and human factors affecting PMMS.

Saunders et al. (2016) also argued that scientific methods are not perfect, and and need to be revised continually in light of evolving theory with an open mind to using new research methods. Creswell (2017) stated that regardless of method forms, researchers should emphasize the research problem and use all approaches needed to fully understand problems and find solutions for it. The study also focuses on a specific context, in which the key stakeholders interact with the management process and guide the process. Although humans behaviour can cause changes in each scenario, the possible outcomes can be predicted throughout statistical analysis. As a result, this research requires a combination of constructivism and objectivism stances to view the current processes used in order to generate the required PMMS framework. Thus, pragmatism is the most suitable philosophy for this study as it combines the views that are used to solve this

research's questions. Researchers can use different necessary forms of data collection and analysis to answer the "what" and "how" questions. Pragmatism is in line with the view (Tashakkori and Teddlie, 2010). This philosophy argues that both constructivism and objectivism are valid ways to approach research. They allow researchers to view a topic from either or both points of view regarding the influence or role of social actors and use these to create a practical approach to research.

3.3 Research approach

Because this research requires a combination of objectivism and constructivism stances, the data collection of current practices is required to develop theories and then to test the theories against existing data. Therefore, the research has been led by a combination of inductive and deductive approaches. It has started with the inductive reasoning to build patterns and theories on PMMS and then used deductive methods to test the hypotheses, leading to the confirmation of the theories. The selection of a research approach is based on the understanding of researchers of the nature of the research questions, the researchers' personal experiences, and the audience of the study (Creswell, 2017). In the literature, there are two broad research approaches, namely the deductive approach and the inductive approach, and their differences are illustrated in Figure 3.1.

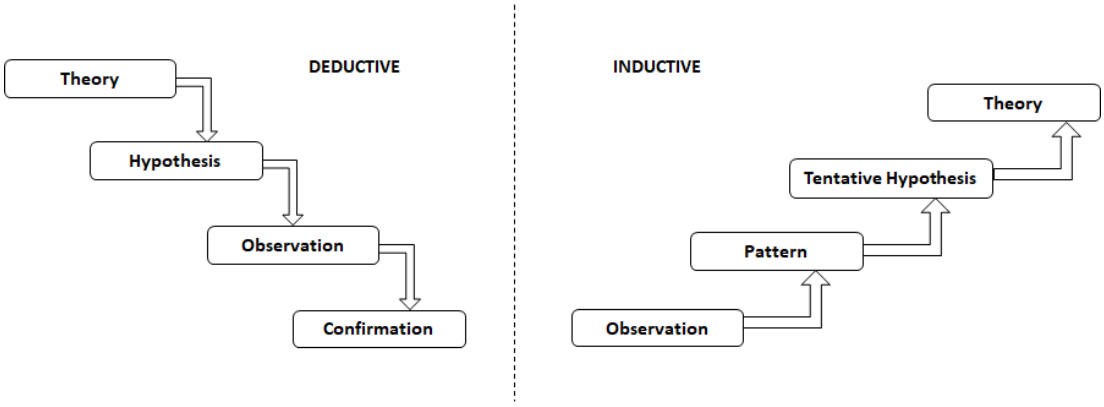


Figure 3.1: Research approaches. Adapted from Trochim and Donnelly (2001).

The deductive approach is a "top-down" approach, which works from the more general to the more specific (Trochim and Donnelly, 2001). Researchers start with a theory about research topics and then develop hypotheses that can

be tested through observation using new empirical data. The original theory can be confirmed (or not) at the final step. The inductive approach works the other way around. Researchers focus on developing new theory from observed data, starting with observation to identify patterns, categories, and themes. When using an inductive process, researchers go back and forth between the categories or themes and the data until the researchers can formulate tentative hypotheses and can then develop general conclusions or theories (Creswell, 2017; Trochim and Donnelly, 2001). Most social research involves a combination of inductive and deductive approach processes at some time in the project (Trochim and Donnelly, 2001). This combination allows researchers to collect data to identify patterns and then generate a new or modified theory (Saunders et al., 2016).

This research requires to identify patterns, categories, and themes by examining the data and then establishing a comprehensive set of themes. In this way an understanding is gained of the social world through data collection at the site where participants experience the issues and problems under study; this fits with an interpretivist epistemology (Creswell, 2017). It also uses a constructivist ontology and focuses on the interactions between individuals rather than phenomena "out there" and separates it from those involved in its construction (Bryman and Bell, 2011). This perspective allows researchers to focus on learning the meaning that the participant experiences about the issue instead of the meaning that the researchers believe the participants should have. On the other hand, view of the relationship between theory and research as deductive, where a hypothesis is deduced from theory and is then tested using the data collected for the study. It has a positivist epistemology perspective and an objectivist conception of social reality. Therefore, Figure 3.2 illustrates the approach of this research.

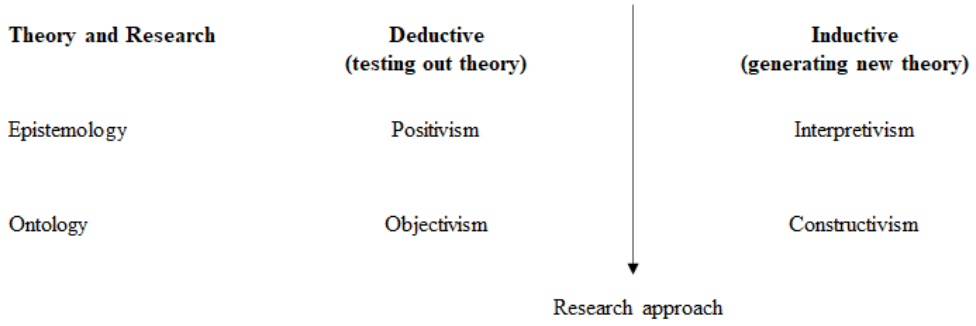


Figure 3.2: Research approach

3.4 Research methods

The most suitable research methods are selected based on the research approach. This research has been led by a combination of inductive and deductive approaches. Therefore, a mixed methods approach has been selected. To use a mixed methods approach, extensive data collection is needed and researchers should be be familiar with both qualitative and quantitative approaches.

It is commonly believed that qualitative research tends to be concerned with words rather than quantification in the collection and analysis of data. Quantitative researchers typically gathers multiple forms of data such as interviews, observations, documents, and case studies. This approach usually includes a smaller sample size as data collection is time-consuming. Also, the data tends to be difficult to automate by way of generalising, leading to difficulties in making a systematic comparisons (Creswell, 2017).

On the other hand, quantitative research is described as involving the collection of numerical data by way of a designed survey. The design provides a quantitative description of trends, attitudes, or opinions of a population by studying a sample of that population (Creswell, 2017). Quantitative research requires description of the purpose of the study, identification of the population and sample, the use of a survey instrument, and the variables and relationships between them. The measurement process in quantitative research involves the search for indicators and establishing the reliability and validity of the measures (Bryman and Bell, 2011). The weakness of quantitative research is that, sometimes, it reflects the view of the researchers instead of the participating subject.

Both quantitative and qualitative research approaches each have their strengths and weaknesses, and they can be very effective in combination with each another. A mixed methods approach is employed for research that combines quantitative research and qualitative research in a single project. This approach allows the research to adopt both inductive and deductive approaches and to balance out the strengths and weaknesses of quantitative and qualitative methods of data collection (Bryman and Bell, 2011). Mixed methods approach have been founds to be useful advantageous for the following types of studies (Creswell, 2017):

- Comparing different perspectives drawn from quantitative and qualitative data
- Explaining quantitative results with a qualitative follow up data collection

and analysis

- Developing better measurement instruments by first collecting and analysing qualitative data and then testing the instrument on a large sample
- Understanding experimental results by incorporating the perspective of the individuals
- Developing a complete understanding of changes needed for a marginalised group through the combination of qualitative and quantitative data
- Having a better understanding of the need for and impact of an intervention program through collecting both qualitative and qualitative data over time.

In mixed methods studies, the qualitative and quantitative data may be equally emphasized, or one may be more emphasized than the other. Data may be collected at the same time or not, and one form builds or connects with the other (Creswell, 2017). Therefore, there have been several types of mixed method strategies which are characterised by types of designs, forms of data collection, data analysis, interpretation, and validity challenges.

This research adopts a multi-phase mixed methods design in respect of the research philosophy, research approaches, and research questions. The relationship between both phase of the mixed methods is illustrated in Figure 3.3. The research first begins by exploring the practice of the PMMS. Qualitative research was selected for Phase 1 because it involved the need to gain a deeper understanding of the current practice of the PMMS, which could be best achieved through field trips, school property brief inspections, and interviews. Findings from Phase 1 contributed to the development of the questionnaire used in Phase 2.

For Phase 2, a maturity assessment model was developed to assess the current maturity levels of responsibilities in PMMS. Then an online questionnaire was created and sent to participants for assessments of responsibilities in PMMS. In Phase 3 the PMMS framework needed to be tested by the end-users, so qualitative research methods were chosen to allow the researcher to collect the end-users' feedback and evaluation. Each type of data was analysed separately and but interpreted together, using the techniques associated with each data type, as discussed in the next section.

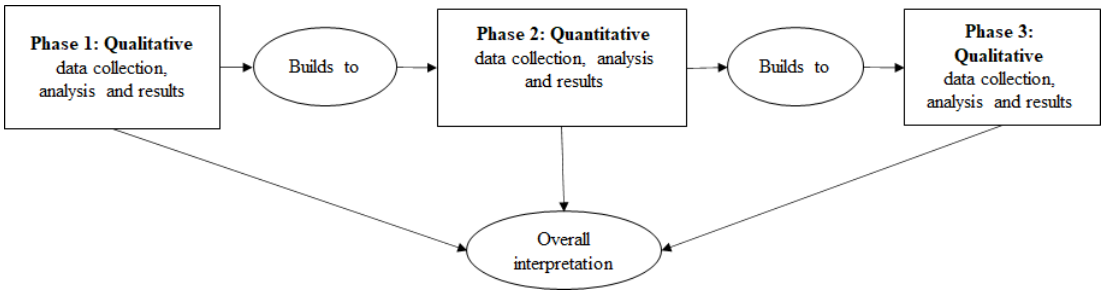


Figure 3.3: Research methods

3.5 Research process

The research process was designed to achieve the research objectives. Each stage of the research is needed to ensure the research will be completed successfully and all research questions will be answered. The number of stages in the research process vary from researcher to researcher. Saunders et al. (2013) argued that although the number of stages are varied, it usually includes identifying a topic, reviewing the literature, designing the research, collecting the data, analysing the data, and writing up the findings. The current study uses five stages for the research: literature review, preliminary study, questionnaire survey, model development, and validation, with the analysis and write up inclusive, as shown in Figure 3.4.

3.5.1 Stage 1: Literature review

The literature review is considered as a critical stage in any research study because it accomplishes several purposes. Firstly, a comprehensive literature review allows the researcher to review the current state of knowledge, enabling them to fully understand the research problems and identify research gaps. The literature review in the current study started with a background study, followed by a consideration of maintenance management and property management in the context of asset management, the maturity level model, particularly the continuous representation, and the NZ state school context. The in-depth literature review has been conducted based on journal articles, books, dissertations, government reports, and other materials that integrate previous related research and identify critical gaps in the knowledge.

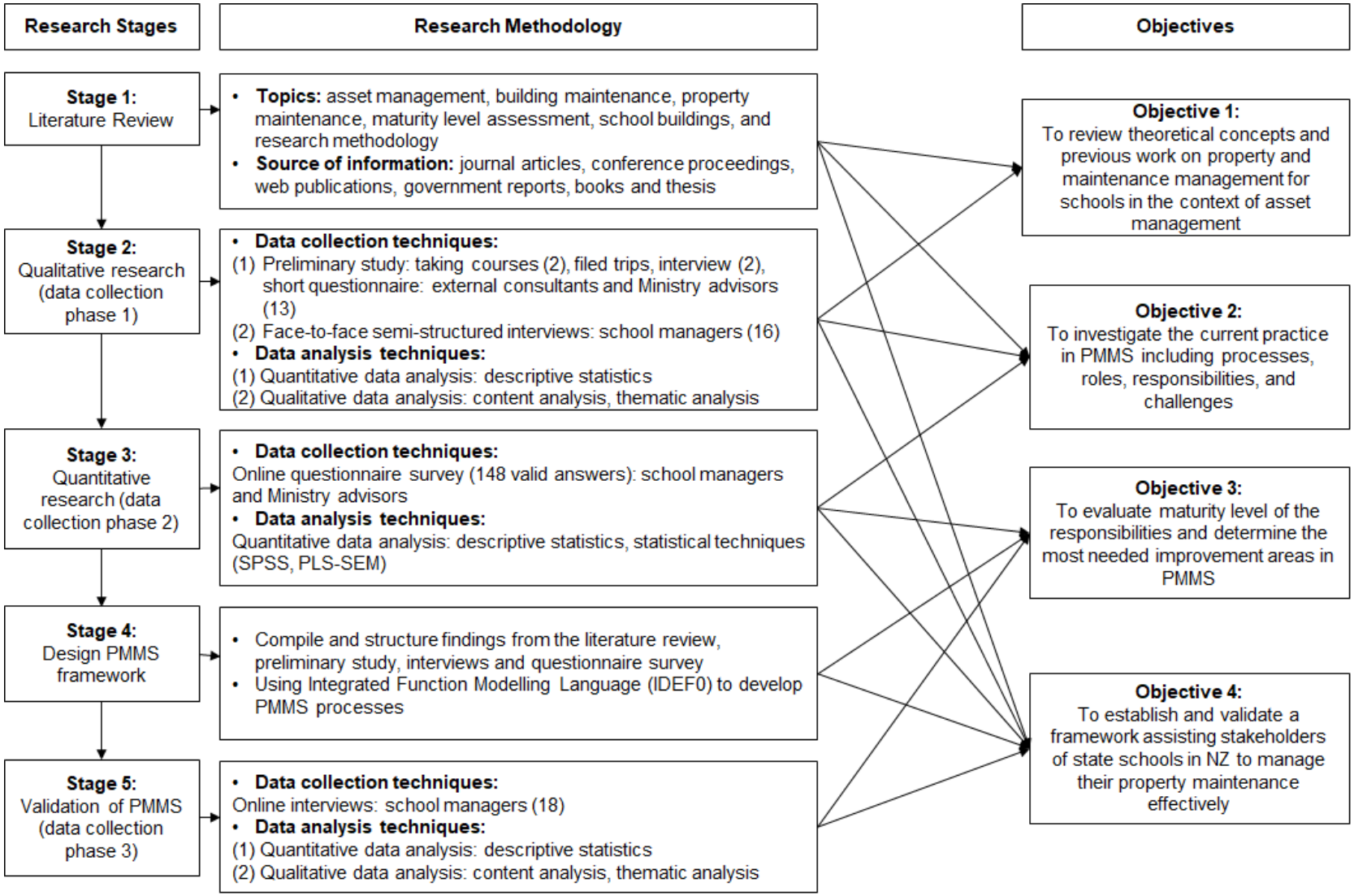


Figure 3.4: Research process and objectives

The keywords used in searching the literature were categorised into three groups. The "asset management" group includes "building maintenance", "property management, "maintenance management". The maturity group contains "maturity level", "maturity model", and "maturity assessment". The NZ school context group consists of "property management in NZ", "NZ state schools", and "school buildings". The categorisation of the keywords enabled the researcher to review previous studies systematically. The search then was gradually extended by focusing on references in relevant texts and key authors as well as reading suggestions from the referencing software. The literature search was also carried out on research methodologies to identify the most appropriate research design for this study. There were there phases of data collection in this research: (1) preliminary study and interviews, (2) questionnaire survey, (3) validation. The details of each phase are presented in next sections.

All documents were reviewed, summarised, and organised according to key themes as presented in Chapter 2. NVivo and Microsoft Excel were used to help manage the literature entries. During the reviewing, and synthesising, the gaps in the existing knowledge were explored and identified. From the review it emerged that many researchers contributed to the body knowledge of maintenance and asset management in the built environment. Different maturity assessment models for the maintenance and asset management have also been well developed and discussed. However, collaboration in the context of property and maintenance management, (a third party maintains properties on the behalf of the owner), has not been thoroughly addressed, especially in the school building context.

The literature review also provided no clear evidence about the effectiveness of the currently used framework in the PMMS in NZ. Challenges and issues in the PMMS were mentioned in some government reports; however, solutions have not been addressed systematically. Hence, it was decided to conduct a preliminary data collection study to clearly identify the research problems and ensure that the main data collection study was on firm ground.

3.5.2 Stage 2: Qualitative research

3.5.2.1 Preliminary study

When the researcher has a limited amount of data, experience or knowledge about a research issue, a preliminary study is needed as an initial exploration of

the issues to identify key features of the research (Harvey, 2004). A preliminary study is an important first step of a project because the decisions taken at this stage determine the direction of the project (Kuster et al., 2015). Additionally, findings from the preliminary study allow researchers to define research problems more precisely, refine relevant courses of action, and evaluate their acceptability, feasibility, cost, and time. In this research study, the preliminary study was based on several formal and informal studies to gain additional insights into the topic area as shown in Figure 3.5.

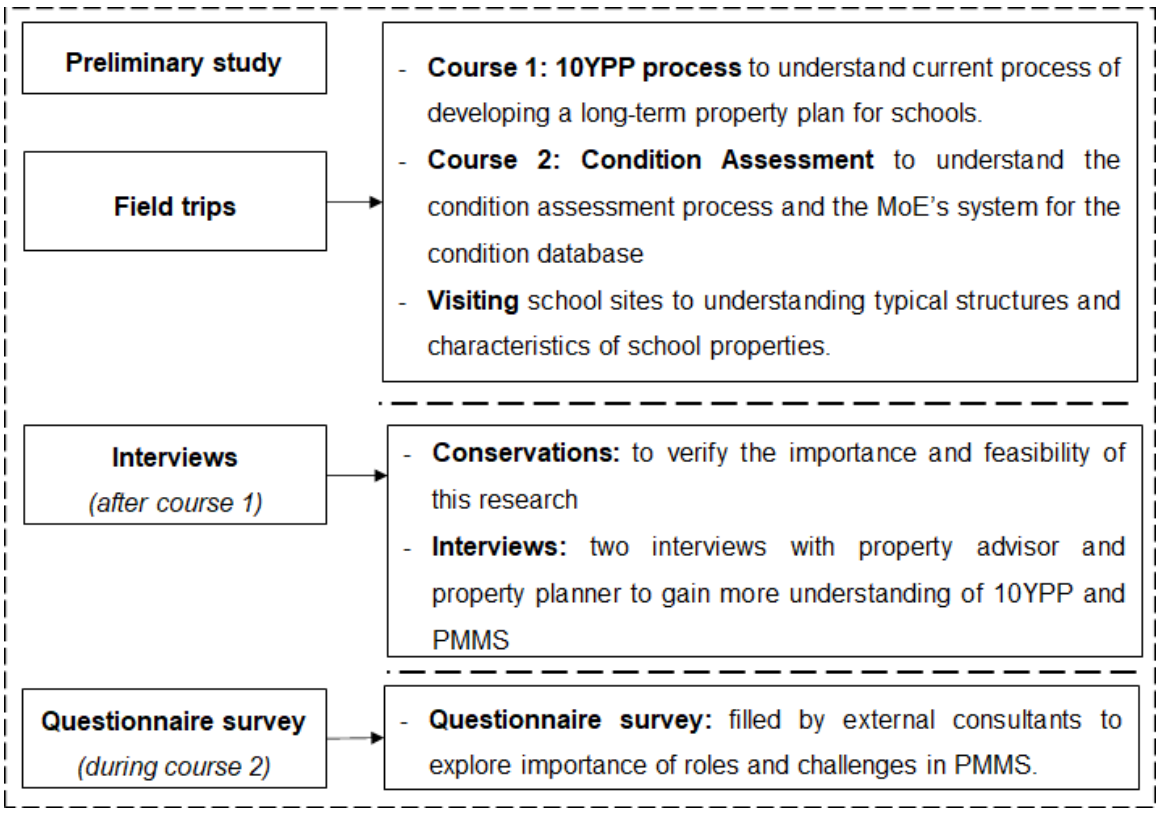


Figure 3.5: Preliminary study

The first activity in preliminary study is attending training courses provided by the Ministry of Education for people involved in the PMMS in October and November 2017. The first course was about the 10YPP process, which is the fundamental process of the PMMS. During this course, the researcher gained an overview of the development of a long-term property plan for schools, including key elements and inputs, producing and presenting the 10YPP. The roles of people involved in the 10YPP process that were discussed as a part of the course also further helped the researcher to identify the key participants in this research.

During the 10YPP course, the researcher had the chance to present this research to the other participants, who were Ministry advisors, external consultants, and school board members. Their feedback verified the importance and feasibility of this research. Also, the researcher had conversations with the people and asked them each for a future interview for further discussion of the "real 10YPP" process in practice. Then, the researcher had a face-to-face interview with a Ministry-engaged consultant (P1) and an online interview with a Ministry advisor (P2). Findings from the interviews are presented in Chapter 4.

The second course was about the condition assessment, which is very important for preparing a property plan for schools. It was held at a school to give a 'real world' context for the participants (different participants from the first course). The condition assessment forms a part of the MoE's overall 10YPP process with the objective of identifying what needs to be done to maintain the school and its current function. A step by step condition assessment process was introduced to help participants apply the process and use the MoE's system to complete and update a sample assessment for this school. During the course, the participants visited all buildings, areas, and systems of the school to produce the assessment. The visit helped the research have a better understanding of the property system in a school in NZ.

At the end of the second course, a short questionnaire was distributed to participants, who were PA, PP and PM. The questionnaire aimed to gain the participants' assessment of challenges in the current PMMS model. Influence of roles of people involved in the PMMS was also investigated in the survey, which allowed the researcher to select the main participants in the next data collection phases. The researcher also collected internal documents in the PMMS during the courses. The Ministry's guidelines on condition assessment, 10YPP, and budgeting were collected and reviewed, which helped the researcher develop a PMMS framework that aligns with the regulation and requirements.

The preliminary study's objectives were achieved by attending the courses, interviewing P1 and P2, visiting the schools' sites, and surveying participants during the second course. The data analysis and findings of the preliminary study are discussed in the Chapter 4.

3.5.2.2 Interviews

Semi-structured interviews were designed to collect schools' perspectives as key stakeholders in PMMS. The interviews were planned to identify processes and activities in PMMS with specific roles and responsibilities of the people involved in those processes. Challenges and issues in the current PMMS were investigated and then compared with findings from the preliminary study.

Due to geographical issues, purposive sampling was used to select the participants representing schools in this stage. The purposive sampling aims to produce a sample that can be logically assumed to be representative of the whole population (Lavrakas, 2008). A list of schools was prepared with specific criteria, including each schools' size, location, and number of students enrolled each year, as the characteristics were mentioned in the interviews with P1 and P2 several times. There is no definition of size of school. The statistics indicate that the average roll size of a primary school in 2018 is 230 students, and the median school roll is around 200. Therefore, in this study, schools have number of students enrolled less than 200 are considered small, schools have number of students enrolled from 201 to 500 are considered medium, and from 501 to 1000 is large, and more than 1000 students are extra-large. Due to the time and resource limit, only 90 schools in the following three regions in NZ contacted; the capital, Wellington (region A), the biggest city, Auckland (region C) and a central city, Palmerston North (region B).

The invitation was delivered to school administrators with a request that it be sent to principals/deputy principals/property managers/business managers/board of trustee members, or whoever else was responsible for property matters at the school. After two weeks, 90 invitation were sent and 16 participants agreed to participate in the research. The interviewees responded with their availability and a confirmation email along with the interview questions was sent to them one week in advance, with follow up reminders sent the day before. Information gathering was stopped after the interview with the 16th participant when no new information or concept was been explored in any of the questions, suggesting that saturation had been reached (Creswell, 2017).

The interview questions were grouped into three parts (refer to Appendix D). The questions in part 1 aim to establish participants' backgrounds and the characteristics of the schools. Part 2 focuses on understanding PMMS process in the school, including collaboration, communication, and information exchange

between the key stakeholders. Part 3 asks about any issues and challenges in PMMS that the schools have been facing and invites suggestions from the participants to solve the problems. Two pilot interviews were conducted to refine the questions and eliminated problems in understanding and answering the questions. These pilot interviews were carried out with one researcher from the Massey University, who had experience with management of public building projects in NZ, and one researcher from the University of Lille in France, who had experience with asset management projects in France. Following the interviews, the questions were refined to improve the clarity of the questions and predict the time needed for the interview.

The interviews were conducted over four weeks between November and December 2018, and each interview lasted about 45 to 60 minutes, which was enough time to understand the current status of PMMS and issues of the management process at the schools. Each field trip was scheduled after the interviews and the legnth of the visits varied from 15 to 60 minutes, depending on the availability of the interviewees. All interviewees were asked to read the participant information sheet and then filled out a consent form before their interview. Permission for recording was asked before the recording started. All interviewees consented to the recording of the interviews for more accurate transcription of their feedback. Thus, the interviews were recorded using a digital voice recorder. The recorded files were transcribed manually and a copy of the interview recording was sent to those interviewees who wanted the transcription. No requests were made by any of the interviewees to further amend or edit their interview transcript.

3.5.2.3 Qualitative Data Analysis

The audio recorded interviews were transcribed manually. Due to the open-ended nature of the interview questions, the interviewees gave long, unstructured answers, and similar concepts emerged at different places within the transcript. Each transcript was read several times and organised into a appropriate manner in order to generate sense of the information. The data analysis followed the steps of thematic analysis suggested by Braun and Clarke (2006) as follows:

- Firstly, the whole data set was thoroughly read to shape initial concepts from the data.
- Next, initial codes of data were developed. Any feature concepts/ideas in

the text the researcher noticed were labelled in the coding.

- Thirdly, a list of the different codes was sorted into potential themes, and all the codes within the identified themes were collated.
- Step four involved reviewing and refining the themes coded in relation to the entire data set until the final list of themes are, the relationship between the themes and the story they tell was decided.
- Finally, the themes were defined and named.

The themes were defined mostly with reference to the findings presented in the literature review and the preliminary data collection. There are also activities and relationships of people involved in the process that were not mentioned in the preliminary study or literature review.

3.5.2.4 Reliability and Validity in Qualitative Data Collection and Analysis

Validity and reliability concepts are traditionally used in quantitative research, but now are also commonly applied qualitative studies (Golafshani, 2003). Patton (2001) stated that validity and reliability are two factors researchers should be concerned about while designing a study, analysing results, and judging the quality of qualitative studies.

Reliability is concerned with the replicability of the research processes and results. The essence of the reliability in qualitative research lies with consistency (Leung, 2015) and to minimise errors and biases in a research study (Yin, 2017). Yin (2017) suggested following a properly documented procedure to establish the reliability of the findings. Therefore, in this research, the documentation procedure followed during the preliminary data collection stage, the validation stage, the data ordering, and data analysis stages have been described in detail throughout this chapter. They are also mentioned in Chapter 1 and Chapter 4. Moreover, the interview questions were sent to the interviewees prior to conducting the interviews, to maintain consistency of the data collection. The list of potential participants was prepared consistently with provided criteria. As data were extracted from the original sources, the researcher verified the accuracy of the transcripts by listening to the audio recorded several times, and transcripts were corrected before commencing with the analysis. Each transcript was analysed following the same procedures, and results were saved in both a Microsoft

Excel file and Nvivo software.

Validity in qualitative research refers to the "appropriateness" of the choice of methodology to answer the research questions; in other words, if the research design is valid for the methodology, and the sampling and data analysis is appropriate to generate accurate results for the sample and context (Leung, 2015). Although some qualitative researchers have argued that the term validity is challenging to qualitative research, the need for qualifying checks for the research outcomes should be defined (Golafshani, 2003). The validity of qualitative research can be assessed starting from the ontology and epistemology of the research (Leung, 2015), which was discussed in the previous sections of this chapter. Bias was also addressed in the discussion of the purposive sampling method. For data collection and analysis, several methods were adopted to enhance validity including methods triangulation (literature review, taking course, filed trips, interviews, survey), theory triangulation (multiple perspectives/theories to interpret data), comments from supervisors, and reviewers for papers published in conference proceedings and journals.

3.5.3 Stage 3: Quantitative research

3.5.3.1 Structural and measurement model

Data collected in state 2 provided information on the activities involved in PMMS in NZ, including details on people involved in the activities. For the purposes of Objective 3, a questionnaire with structured questions was employed to evaluate maturity level of responsibilities in PMMS and explore the relationships between the key stakeholders. A structural model was established with five constructs/latent variables who are key stakeholders in PMMS (PO, PA, PP, PM, SC), as shown in Figure 3.6. The latent variables were symbolised by circle symbols and relationships between the key stakeholders are hypothesised from H1 to H10 as follows (development of the hypotheses is explained in Chapter 4, section 4.3.5):

- H1: PO positively influences the maturity level of PA
- H2: PO positively influences the maturity level of PM
- H3: PO positively influences the maturity level of SC
- H4: PO positively influences the maturity level of PP
- H5: PA positively influences the maturity level of PP

- H6: PA positively influences the maturity level of SC
- H7: PA positively influences the maturity level of PM
- H8: PM positively influences the maturity level of PP
- H9: PM positively influences the maturity level of SC
- H10: PP positively influences the maturity level of SC

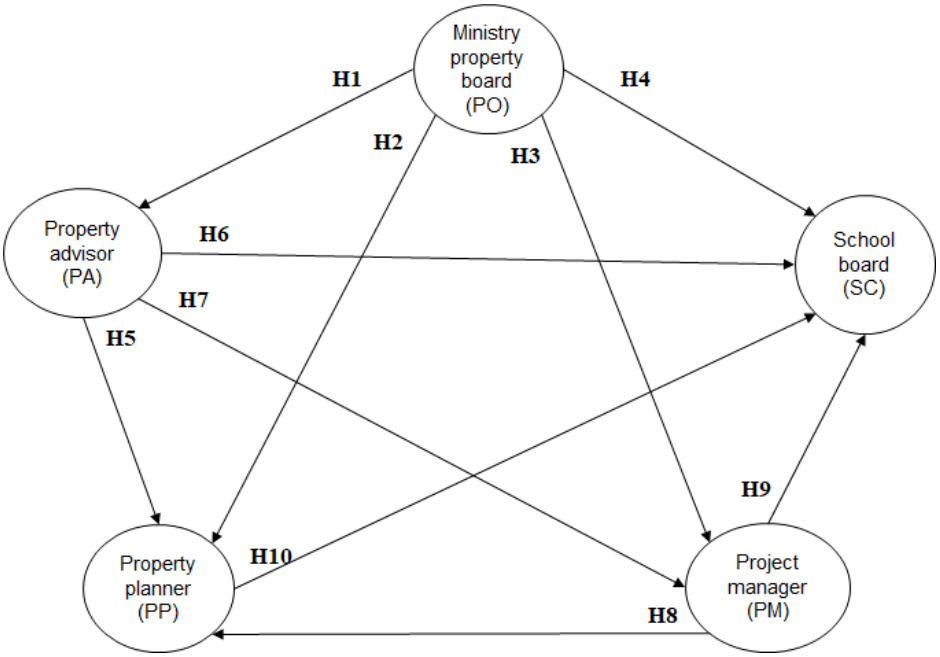


Figure 3.6: Structural model

Findings from stage 2 also formulated the measurement model of the variables. Indicators were identified from responsibilities of PO, PA, PP, PM, and SC. The measurement model consisted of multiple indicator variables which were the item scores in the questionnaire. Each latent variable consisted of a linear combination of multiple indicator variables as shown in Figure 3.7.

A maturity model was developed to examine the maturity level of responsibilities in PMMS. The purpose of this assessment was to identify the weakest points/ greatest issues in PMMS provision and to then develop suggestions for improvement of existing processes at NZ schools. The maturity model used in the research questionnaire survey was adapted from the structure, definitions, and distributes of the ISO 55000 assessment model. As shown in Figure 3.8, there are also six levels of maturity in this model. Characteristics of each maturity level were defined including understanding, goals, and resources for each

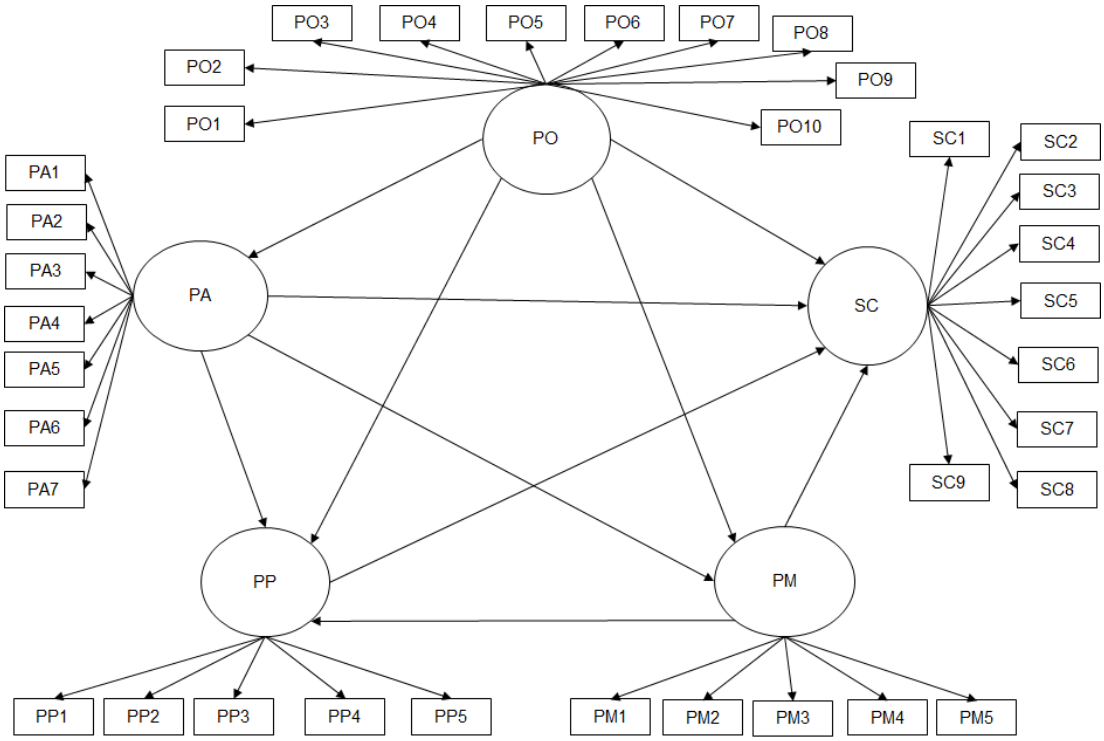


Figure 3.7: Measurement model

level. The model has five process areas: PO, PA, PP, PM, and SC, and overall, 36 activities associated with the process areas were identified from the results of the interviews as discussed in Chapter 4.

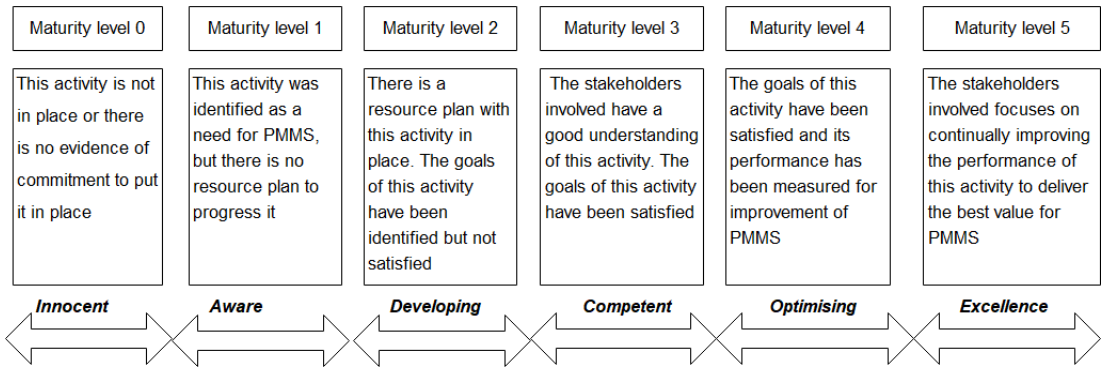


Figure 3.8: Maturity assessment model for PMMS

3.5.3.2 Questionnaire population

The questionnaire was designed to collect data on the maturity levels of all processes involved in PMMS and therefore participants were needed that were familiar with all processes. Based on this consideration, the choice fell on SC and PA, who are involved in all PMMS processes, while other stakeholders such as external consultants only take part in certain tasks. The invitation was delivered to property advisors (PA), and who is responsible for property and maintenance management in schools (SC).

The list of all state schools in NZ was downloaded from the MoE's website, accessed June 2019. Overall, there were 2056 schools in the list, excluding special school. The schools on the list were ordered by number of students enrolled in 2018. Determining the sample sizes involves resource and statistical issues. In most studies the sample size is determined effectively by two factors: (1) the nature of data analysis proposed and (2) estimated response rate (Alshibly, 2015).

In terms of the data analysis method, Partial Least Squares Structural Equation modelling (PLS-SEM) was considered to be an appropriate method to test the hypotheses for this research study (explained later). Hair Jr et al. (2016) discussed that the minimum sample size should be considered against the background of the model and data characteristics. As a rough guideline, the minimum sample size in a PLS-SEM analysis should be equal to the larger of the following (10 times rule): 10 times the largest number of structural paths directed at a particular construct in the structural model. Thus, according to Figure 3.6, SC has the most directed paths (4), 4*10 = 40 represents the minimum number of observations needed to estimate the PLS path model in Figure 3.7. Cohen (1992) recommended that for multiple regression analysis, a construct with 10 variables would need 91 observations to detect the coefficient of determination (R^2) of around 0.25, assuming a significance level of 5% and a statistical power of 80%. Therefore, approximately 100 responses for the questionnaire for this study was considered satisfactory for the purpose of PLS-SEM approach for data analysis.

Alternatively, based on the response rate of the interviews in Phase 1, the minimum number of participants for Phase 2 was estimated at R = 14%. The sample size posed several restrictions to the confidence levels and margins of error. It is recommended to estimate the sample size using a confidence level of 95% and a margin of error between ±5% to ±10%. The researcher prepared

a table featuring the sample size with different margin of error levels as shown in Table 3.1. The calculation of the sample size followed a tool published online (https://blog.flexmr.net/sample-size-calculator) using the original equation given in equation 3.1:

$$S = (\frac{z^2(d(1-d))}{e^2})/(1 + \frac{z^2(d(1-d))}{e^2}) \tag{3.1}$$

S = sample size, P = population size, z = z-score, e = margin of error, d = standard deviation. In this calculation, each confidence level is translated to a z-score.

Considering the two sampling methods above, the researcher decided to approach half the population (around 1000 SC, ±8%). Thus, the questionnaire survey was sent to schools of even order numbers on the list (every second school). Twenty-four schools' email were not available. Therefore, an invitation email was sent to 1,016 schools on the list. The email was sent to school principals' email address (80%), and to the administration office instead (if school principals' email address was not available), asking the staff to forward the invitation to the right people.

Table 3.1: Sample size

N	**±5%**	**±6%**	**±7%**	**±8%**	**±9%**	**±10%**
2032	324	236	179	140	113	92
R = 14%	2,314	1,685	1,278	1,000	807	657

The sample for PA was based on the contact information of the 48 PA listed on the MoE's website. The invitation email was sent to all of them. After five weeks, 185 responses to the questionnaire were received, and 148 answers were valid for the data analysis, while 27 responses were not completed. The response rates of participants in schools was 17.3% (176/1016), while the rate for property advisors was 18.8% (9/48). The average response rate for participants was 18.2% and the rate of valid responses was 14.5%.

3.5.3.3 Developing and delivering the online questionnaire

Based on the findings from the preliminary study and interviews, the questionnaire was developed according to the responsibilities of PO, PA, PP, PM, and SC. All identified activities of PMMS were embedded in the related constructs. The

questions were grouped into three main sections, excluding the covering letter and consent form. Participants were asked questions about their backgrounds and the schools' information in section 1. The second section of the questionnaire was designed to identify the current maturity level of PMMS, with five sub-sections about the responsibilities of PO, PA, PP, PM, and SC. The results of the second section were used to test the measurement model and structural model. The third section consisted of an open-ended question to ask participants about their views and opinions for further improvement of this research.

The questionnaire was tested by six people, namely four academics and two property managers. Two researchers at the School of Built Environment at Massey University, one statistician from Victoria University of Wellington, and one researcher who was working in Australia. All the researchers were experts in quantitative research. The questionnaire also was tested by two property managers, who were involved in Phase 1 of data collection for this study. The pilot study was carried out to refine the questionnaire by eliminating any remaining ambiguities from the questions. The time to complete the questionnaire was set for 15 to 20 minutes. The questionnaire, which was launched on the 23rd of October, was available on the Qualtrics platform for five weeks starting on 23rd October 2019. Reminder notices were sent twice in November 2019. The questionnaire was officially closed on 30th November 2019 and the item scores were downloaded. Analysis started immediately afterwards.

A cover letter explaining the research's rationale and a consent form were added to the first page of the questionnaire survey. The sponsor (Massey University) were represented by its logo on every page of the questionnaire. A list of people to contact for this research (the researcher and main supervisor) if any participant had any concerns was also attached. Other relevant information included in the cover letter are an explanation of the research and the purpose of the questionnaire, the importance of participating in the questionnaire, expected outcomes, the privacy and confidentiality policy, and information on the ethics approval for this research.

3.5.3.4 Quantitative data analysis

The statistical analysis proceeded in three steps. In the first step, a descriptive analysis of the data was conducted. In the second step, the maturity level of the variables were calculated with an analysis of the weakest points in PMMS. In the

third step, structural equation modeling (SEM) was conducted to test all of the hypotheses.

Fist step: Survey data were extracted from Qualtrics in the form of a MS Excel file. The data was first scrutinised to screen out responses that did not meet the quality criteria set for the responses. The screened responses were then converted from raw form to a classified form that are more appropriate for the analyses. Finally, the data was coded for SPSS and PLS-SEM. The analyses were undertaken using SPSS to calculate the average of the item scores for each variable. A descriptive analysis of the scores was conducted, using frequency distribution histograms, and the computation of descriptive statistics (mean and standard deviation).

Second step: The maturity level data was analysed using similar techniques to those discussed the first step. Different groups of participants were categorised to provide a comparison between SC and PA's assessment. The maturity levels were also calculated for each activity in PMMS. The results provide a critically analysis in order to identify the weakest points and to drive improvements of the delivery of PMMS subsequently. The decision-makers analyse the actual status of the activities by looking at the weakest points and then considering potential improvement options for the management.

Third step: Many researchers employed the PLS-SEM approach for exploratory studies to establish a new structural relationship for multi-variables (Alshibly, 2015; Gamil et al., 2020). PLS-SEM is a technique that can analyse structural equation models involving multiple-item constructs with direct and indirect paths (Alshibly, 2015; Hair Jr et al., 2016). The PLS-SEM analysis involves a two-step procedure: measurement model assessment (relationships between constructs and their corresponding indicators), and structural model assessment (relationship among constructs). This study aims to explore the relationships among key stakeholders in PMMS. Therefore, PLS-SEM was applied to validate the constructs used in this study and to test the research hypotheses.

The PLS-SEM method was used to estimate the standardised factor loadings and structural model path coefficients to examine the relationships between constructs and their indicators. The indicators are presented by rectangular symbols while latent variables or constructs are defined by circles, which are computed by the cluster of indicators (see Figure 3.7). The arrows leading from the constructs

to the clusters of indicators represent a reflective relationship. The latent variables are computed from the indicators in the form of using factor loading scores. The arrows drawn between pairs of constructs represent the path (β) coefficients, which indicate the relative strengths or direction of the correlations between the two constructs.

A PLS-SEM analysis involves two stages: (1) the assessment of the measurement model (the relationships between constructs/latent variables and their corresponding indicator variables using factor analysis), and (2) the assessment of the structural model (or path analysis, the relationship among constructs/latent variables) (Alshibly, 2015; Alzahrani, 2015). The structural model presents the path relationship between the latent variables. And research hypotheses might be established. Each hypothesis predicted significant positive relationships between two or more latent variables. The significance of the relationship was tested using a bootstrap resample procedure and the "significant positively" term implies: (1) the statistical significance of the estimated path coefficients (β), and (2) the ability of the model to explain the variance in the dependent variables, coefficient of determination R^2 (Alshibly, 2015). The measurement model shows how each construct is measured by its corresponding indicator variables. The measurement model generates loadings and weights between the latent variables and their indicators, standardised regression coefficients between constructs, and coefficients of multiple determination for dependent variable (Davcik, 2014).

The assessment of measurement model and structural model for this study were conducted using Smart-PLS software. The procedures of using Smart-PLS to construct the PLS path model followed the guidelines as set out in the user instruction manual (Hair Jr et al., 2016) and were carried out automatically by the software, with no intervention from the researcher. The data was imported into Smart-PLS in the form of a comma delimited (CSV) file, with the questionnaire item scores in the columns, and the respondents in the rows. The relationships between the latent variables were defined by the hypothetical model illustrated with a path diagram in Figure 3.6.

3.5.3.5 Validation of the measurement model and structural model

The first steps in the validation is for researchers to evaluate the reliability and validity of measurement models. In measurement models, several individual variables are used to measure a concept based on the assumption that the variables

(indicators) represent all the different aspects of the concept. The quality of the measurement model was assessed by the following measures (Hair Jr et al., 2016):

- Internal consistency reliability (Composite reliability) assesses the correlation between the indicators measuring the same construct. The composite reliability varies between 0 and 1, with higher values indicating higher levels of reliability. Cronbach's alpha is a conservative measure of internal consistency reliability. Cronbach's α has scored in [0,1], and a higher value of the score means greater reliability of the measurement of the research;
- Indicator reliability: High factor loadings on a construct indicate that the associated indicators have much in common, which is captured by the construct. At a minimum, all indicators' outer loadings should be statistically significant. The indicator's outer loadings should be higher than 0.7. Indicators with factor loadings between 0.40 and 0.70 should be considered for removal only if the deletion leads to an increase in composite reliability and AVE above the suggested threshold value;
- Convergent validity: A common measure to establish convergent validity on the construct level is the average variance extracted (AVE). The minimum suggested value of the AVE is 0.5. Convergent validity is adequate when constructs have an AVE greater than 0.50, the variance shared with a construct, and its measures are higher than the error. Conversely, an AVE of less than 0.50 indicates that, on average, more error remains in the items than the variance explained by the construct;
- Discriminant validity: is the extent to which a construct is not highly related to other constructs. An indicator's outer loadings on a construct should be higher than all its cross-loadings with other constructs; the square root of the AVE of each construct should be higher than its highest correlation with any other construct (Fornell-Larcker criterion).

After checking the validity of the measurement model there was sufficient justification to run the Smart-PLS algorithm to compute the model parameters (β coefficients and R^2 values) in order to evaluate the structural model. As suggested by Hair Jr et al. (2016), the following criteria were applied to validate the structural model:

- Examine each set of predictors in the structural model for collinearity. Each predictor constructs' tolerance (VIF) value should be higher than

0.20 (lower than 5). Otherwise, consider eliminating constructs, merging predictors into a single construct, or creating higher-order constructs to treat collinearity problems;

- Use bootstrapping to assess the significance of path coefficients. The number of cases should be equal to the number of valid observations in the original sample. Critical values for a two-tailed test are 1.65 (significance level = 10%), 1.96 (significance level = 5%), and 2.57 (significance level = 1%);
- PLS-SEM aims at maximising the R^2 values of the endogenous latent variable(s) in the path model. While the exact interpretation of the R2 value level depends on the particular model and research discipline, in general, R^2 values of 0.75, 0.50, or 0.25 for the endogenous constructs can be described as substantial, moderate, and weak, respectively;
- Predictive relevance: Use blindfolding to obtain cross-validated redundancy measures for each endogenous construct. As a relative measure of predictive relevance (q^2), values of 0.02, 0.15, and 0.35 respectively indicate that an exogenous construct has a small, medium, or large predictive relevance for a certain endogenous construct.

3.5.4 Stage 4: Framework development

The methodology used for the development of the new framework proposed in this research is based on the Plan, Do, Check, Act cycle (PDCA). The PDCA cycle concept was developed by William Deming (1950s) as a method for continual improvement of processes or systems and changing management practices. It helps improve the performance of processes systematically. The four steps of the cycle can be summarised as follows:

Regularly improved, the PDCA cycle has been applied across industries and organisation types (Gidey et al., 2014). The PDCA cycle has also been used for the development of the ISO 55000 framework (Patiño-Rodriguez and Carazas, 2019), which helps organisation achieve standards of ISO 55000. Márquez, López, Rosique and Márquez (2018) argue that the framework offers opportunities for top management to re-examine and refine their management model. It also helps to improve relationships between key stakeholders and enhance stakeholders trust.

Van Der Voordt et al. (2016) adopted the PDCD cycle to develop a new value-adding management model for cooperate real estate management. The key actions in their new model was to define interventions that may add more value to the organisational objectives. Because of the benefits of the PDCA cycle, it was adopted to develop the new framework, which includes one more stage (Establish-Plan-Implement-Evaluate-Improve).

The Integrated Function Modelling Method (IDEF0) was adopted to develop the lower level of the framework. The principal strength of the IDEF0 method is that it is effective in describing activities and detailing system activities (Integrated DEFinition Methods (IDEF), 2019). IDEF0 enables the description of processes using greater detail of each activity, meaning that users can more easily understand the progress and see which areas should be improved. As show in Figure 6.1, the IDEF0 technique uses simple modelling language of boxes and arrows, which makes it easy for users to understand and interpret the information. The hierarchy details of the activities also help increase the effectiveness of communication between all people involved in the process. The method was employed to both develop the framework for building maintenance management for schools (Akasah et al., 2010), and enhance collaboration in construction projects (Erdogan et al., 2008). Therefore, IDEF0 has been recognised as the most appropriate method for modelling processes such as those involved in PMMS.

3.5.5 Stage 5: Framework validation

Based on the findings from Stage 4, the proposed model was validated using qualitative research. Data collection for the validation was planned for April 2020 and interviews and focus group workshops were identified as the most appropriate data collection method. However, due to the Covid-19 pandemic, the data collection was postponed to August 2020, at which point the availability of people was limited. Therefore, online interviews were carried out via Zoom.

The validation study further explored the potential implementation of the proposed model into practice. The validation process was conducted in two stages: The first stage involved pre-validation discussions with three researchers who have a background in and knowledge of project management, facility management, and building technology. The researchers were from Massey University, NZ (1), National University of Civil Engineering, Vietnam (1), and Heriot-Watt University (UK) (1). The purpose of the pre-validation discussions were to reduce poential

comprehension issues of the interview questions.

Purposeful sampling technique was used for the identification and selection of the most suitable participants, who are experienced and knowledgeable in PMMS. Therefore, the invitation then was sent to those who were involved in the data collection Phase 1 and Phase 2 and wanted to take part in Phase 3. Seventy-six emails were sent and eighteen people accepted the invitation. Unfortunately, no PA was available during the validation time frame. Three PA responded to the invitation email, saying that they had been very busy with restarting all work suspended since the lock down in NZ (from March to June, 2020), so they would not be able to help this time. Therefore, the validation was only conducted with SC.

The validation interview template consisted of two sections. The first section was the researcher's introduction of PMMS framework and the relationships between the activities in PMMS. The second section aimed to examine the appropriateness of the proposed PMMS and identify a suitable implementation strategy for it (refer to Appendix A5). The time allocation for the interview was 30-45 minutes and the proceedings consisted of: introduction to PMMS framework (15 minutes); assessment (10-15 minutes); implementation strategy (10-20 minutes) and further thoughts (5 minutes). Eighteen interviews were conducted over approximately three weeks between August 2020 and September 2020. The data gathered through semi-structured interviews were analysed following qualitative data analysis methods used in Phase 1. Findings of Phase 5 are presented in Chapter 6.

3.6 Summary

This chapter presented the research methodology adopted in this research study to achieve its aims and objectives. The nature of the research questions and the specific context of this research led this study to adopt a combination of both the deductive and inductive approaches. A preliminary data collection study was carried out which involved taking a training course as well as conducting interviews and a short survey questionnaire to establish a firm base for the research. Then semi-structured interviews were conducted to investigate the challenges in current practice and form the research hypotheses. A questionnaire was used to identify the maturity level of PMMS and examine the relationships among the

key stakeholders to test the research hypotheses. Online semi-structured interviews were conducted to validate the developed PMMS framework. The chapter also explained the data collection processes including the sampling, preparation and contents of interview templates, as well as questionnaires and pilot studies. This research study used thematic analysis to examine the qualitative data, while descriptive statistics and PLS-SEM were used to analyse the quantitative data. Finally, the chapter discussed the validity and reliability of the findings both in quantitative and qualitative research.

Chapter 4

Preliminary Study and Interviews

4.1 Introduction

In the literature review chapter, it was highlighted that a preliminary study is needed to further understand the current practice and then refine the research objectives. This chapter outlines the findings from the preliminary study and main interviews as presented in Figure 4.1. The purpose of the preliminary study was to gain an in-dept understanding of the current processes and identify what issues to focus on in the main study. Therefore, a mix of field trip, questionnaire, and interviews were used in the preliminary study to review current practice and gain deeper understanding of the current process in PMMS. Findings from the preliminary study contribute to development of questions in the main interviews.

The main interviews with SC were conducted for the qualitative data collection in this research. The purpose of the interviews was to identify challenges of the existing processes in PMMS. Findings of the interviews also helped identify key constructs and factors affecting PMMS, which were used to develop the questionnaire for the quantitative data collection. A maturity assessment model was developed and then distributed to the participants to identify the current maturity level and weaknesses of PMMS.

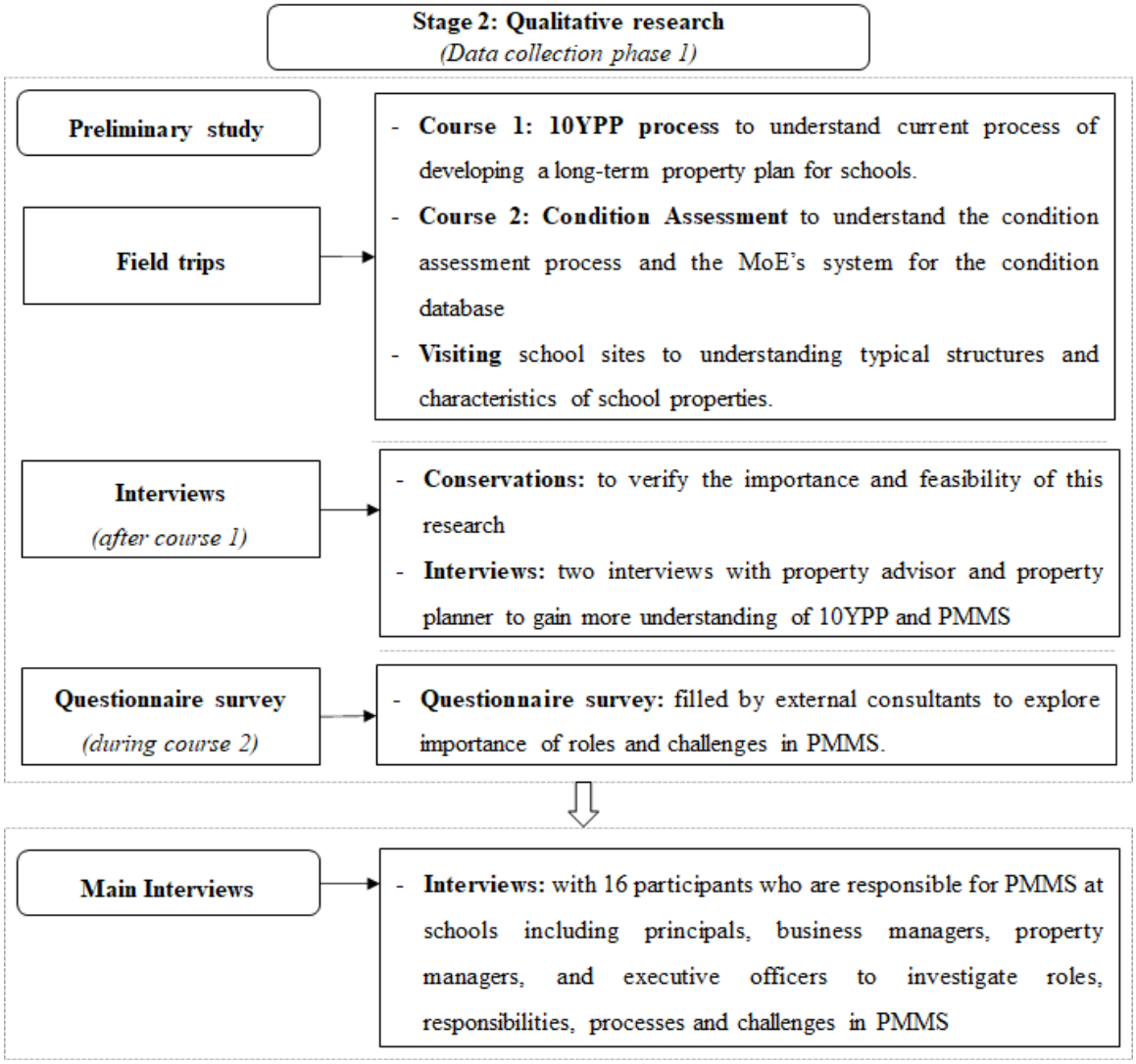


Figure 4.1: Preliminary study and interviews

4.2 Preliminary study

4.2.1 Field trips

The field trips were conducted through attending courses and school site visits. The researcher gained an overview of function areas, layout, structure, material, and infrastructure system of schools and how to do the assessment to provide a forecast of the school's future maintenance liability. The researcher had a chance to talk to the participants about their views on the challenges in PMMS.

The researcher attended two training courses provided by the MoE for people involved in the PMMS in October and November 2017. The first course was about

the 10YPP process, which is the fundamental process of the PMMS. During this course, the researcher gained an overview of the development of a long-term property plan for schools, including key elements and inputs, producing and presenting the 10YPP. The roles of people involved in the 10YPP process that were discussed as a part of the course also further helped the researcher to identify the key participants in this research.

During the 10YPP course, the researcher had the chance to present this research to the other participants, who were Ministry advisors, external consultants, and school board members. Their feedback verified the importance and feasibility of this research. Also, the researcher had conversations with the people and asked them each for a future interview for further discussion of the "real 10YPP" process in practice. Then, the researcher had a face-to-face interview with a Ministry-engaged consultant (P1) and an online interview with a Ministry advisor (P2). The ideas from the interviews are discussed in the next section.

The second course was about the condition assessment, which is very important for preparing a property plan for schools. It was held at a school to give a 'real world' context for the participants (different participants from the first course). The condition assessment forms a part of the MoE's overall 10YPP process with the objective of identifying what needs to be done to maintain the school and its current function. A step by step condition assessment process was introduced to help participants apply the process and use the MoE's system to complete and update a sample assessment for this school. The researcher also collected internal documents in the PMMS during the courses. The Ministry's guidelines on condition assessment, 10YPP, and budgeting were collected and reviewed, which helped the researcher develop a PMMS framework that aligns with the regulation and requirements. During the course, the participants visited all buildings, areas, and systems of the school to produce the assessment. The visit helped the research have a better understanding of the property system in a school in NZ.

The primary schools visited all had sites smaller than 2.5 hectares. The secondary schools tended to be bigger, with site areas ranging from 5 to 8 hectares, with 8,600 m2 to 15,000 m2 used for building areas. Despite the size differences, all primary schools had certain common functional areas such as offices for the administrative staff, classrooms, learning areas, library, kitchen/food preparation areas and toilet areas. The secondary schools had some extra functional areas,

namely laboratories, a gymnasium, sports areas and a technology block to meet the requirements of teaching and learning for some courses. Some primary and secondary schools had swimming pools while all schools had car park areas, gate, fencing, trees, and lawn areas. All schools were also equipped with a heating system, ventilation system, security system, communication system, fire protection system, hot and cold water, and external drainage as essential building services. The school visits allow the research shape an understanding of school property portfolios. Despite the size differences, buildings and infrastructure system is similar in primary and secondary schools. It is still in need to explore how stakeholders perform their roles and tasks in PMMS in order to achieve the defined objectives.

4.2.2 Preliminary study interviews

The interviews with P1 and P2 provided the researcher with insights into the ideas, concerns, focus and viewpoints of experienced people and newbies in this area as P1 has been working in PMMS field since 1990, while P2 had just started the job the year before. A semi-structured interview framework was used to cover key themes and questions related to current processes and activities in PMMS.

P1 usually engages with four to five schools annually to prepare their 10YPP and manage 5YA projects. P1 provided examples of challenges in working with schools in his areas as he felt that the school boards were not very interested in PMMS, and the frequent change of school board members prevents the development of a long-term vision for their school asset management. There is a limited understanding by the school boards of the MoE's long-term property strategy. Also, P1 experienced geographical issues of small and isolated schools: "these schools are facing much more difficulties in managing their properties with very limited budget and isolated location". Additionally, P1 added that "funding for PMMS is not enough" and suggested that the funding stream should be reviewed and actions should be produced accordingly and in a more timely fashion as "responses from the Ministry are quite slow".

P2, on the other hand, voiced other concerns. P2 just started this job and was working with 12 schools at that time. P2 found that communication between people involved in the process was a challenge. "An experienced Ministry advisor usually manages 35-50 schools" that requires effective communication between PA and others to ensure that the work can be done efficiently.

Both P1 and P2 mentioned that they found issues in information exchange and historic data in the current process. They also raised a concern about the collaboration among people involved in the process to achieve the long-term strategy of PMMS.

The findings from the literature review and interviews with P1 and P2 informed the design of a short questionnaire that sought establish the prevalence of the challenges in PMMS identified by the participants. The questionnaire was distributed to the participants, who were working as external consultants in PMMS, in the second course on "Condition Assessment".

4.2.3 Questionnaire survey in preliminary study

At the end of the second course, a short questionnaire was distributed to participants, who were PA, PP and PM. The questionnaire aimed to gain the participants' assessment of challenges in the current PMMS. Influence of roles of people involved in PMMS was also investigated in the survey, which allowed the researcher to select the main participants in the main data collection phases.

The survey was designed to explore the importance of roles in planning and implementing property projects in PMMS, and challenges in the process. Although the thirteen participants who participated in the second training course are not representative of the wider population involved in the process, their perspectives and ideas contributed to the research hypothesis development. Of the thirteen participants, seven worked as PM, three as PP and three as PA. Two participants, including one PM and one PP, had more than 10 years of experience in their positions; six participants spent five years to ten years working with school property projects; and five participants had less than 5 years of experience in this field. Ten participants had been working with schools in the North Island and three participants were working in South Island areas.

The first part of the questionnaire asked about the level of influence (score from 1 to 5 as very low to very high) of SC, PA, PP, and PM in PMMS. The results show that PA and SC are believed to have a strong influence in both the planning and implementing stages. Participants thought that PP are ascribed high importance for the planning stage but less importance for the implementation stages. Instead, PM are considered to be very important during the implementation stage as opposed to the planning stage.

The second part investigated participants' assessments of challenges in current

PMMS. Thus, the survey offered participants a list of 8 groups of challenge that were identified from the interviews with P1 and P2 in the preliminary study. Participants were presented with statements saying that this was a central challenge to PMMS delivery. Participants were then asked to indicate their agreement with the statement on a scale of 1 to 5 (with 1 indicating a strong disagreement that it is a relevant challenge and 5 marking strong agreement). The challenges deemed most prominent by the majority of the participants received a code (C1 to C8) and are listed below:

- C1: Understanding and interest of schools in the PMMS
- C2: Competence of people involved
- C3: Collaboration of people involved in 10YPP process
- C4: Collaboration of people involved in managing 5YA projects
- C5: Information transparency between stakeholders
- C6: Budget allocation
- C7: Historic data of previous projects
- C8: Monitoring process to ensure that the strategic goals are achieved

Eight of the thirteen participants agreed with challenges C4 and C7, and seven participants selected "agree" or even "strongly agree" for C3, C5, and C6. Overall, C3, C4, C5, and C7 (collaboration, communication and information management) were rated the most challenging factors in PMMS. However, members of the three job groups (PP, PM, PA) featured among the participants differed with regard to what they considered to be the most challenging factors. The PM group gave the highest score to C5 and C7, while the PA group gave C5 and C8 the lowest score, and the PP group gave C7 the lowest score and C8 one of the highest scores. The results indicate that PP can access historical data of previous projects more easily than PM (C7). Moreover, PP and PM found the communication process in PMMS to be less effective than PA (C5), while all groups agreed that the collaboration of people involved in 5YA projects was one of the most challenging factors in PMMS. Based on these findings, the challenges identified as most pressing were chosen to be explored in greater detail in the main part of the study.

The preliminary findings show that SC play an important role in PMMS. The PA, PP, and PM also addressed that the most challenging aspect of the delivery

of PMMS was the collaboration of people involved. The challenges needed to be examined from the perspectives of school managers, who play a critical role in PMMS. Therefore, interviews with school managers were conducted and the findings are presented in the next section.

4.3 Main interview analysis

4.3.1 Interview participants' backgrounds

The summary of the background of 16 participants involved in the main interviews is presented in Table 4.1. Nine participants were principals/deputy principals who carried the ultimate responsibility for the property management at their schools. The rest of the participants included one property manager, three executive officers, and three business managers, who were in charge of the property management at their schools. Nine of the participants had been working in the area of school property management for over ten years, and others have had at least two years of experience in their current position. Seven participants were working for primary schools (coded P1 to P7) while nine participants (coded S8 to S16) were serving at secondary schools.

The recruited schools' sizes are varied. Seven primary schools have school sites smaller than 2.5 ha with general building areas under 3,000 m2, and five of them have a number of students enrolled each year is approximately 350 students while the other two enroll less than 200 students each year. The secondary schools are bigger with the site areas from 5 to 8 ha and 8,600 m2 to 15,000 m2 of general building areas. Two secondary schools enrol more than 2,000 students each year, and three of the secondary schools enrol over 1,000 students each year. Regardless the size, the schools have similar functional areas such as administration, classroom, learning areas, library, kitchen/food preparation areas and toilet areas in each primary school. In secondary schools, there are some extra functional areas such as laboratory, gymnasium, sports areas and a technology block to meet the requirements of teaching and learning for some courses. Some schools have swimming pools, while all schools have car park areas, gate, fencing, trees and landscape. The schools also are equipped with a heating system, ventilation system, security system, communication system, fire protection system, hot and cold water and external drainage as essential building

services in the schools. According to the site visits after each interview, the researcher found out that schools' building conditions are varied depending on the building ages and available resources.

Table 4.1: Participants' background

No	Code	Position	School Type	Student	Years of experience
1	P1	Principal	Primary	201-500	over 10 years
2	P2	Principal	Primary	201-500	5-10 years
3	P3	Principal	Primary	201-500	2-5 years
4	P4	Executive Officer	Primary	Up to 200	5-10 years
5	P5	Executive Officer	Primary	201-500	5-10 years
6	P6	Executive Officer	Primary	Up to 200	5-10 years
7	P7	Principal	Primary	201-500	5-10 years
8	S8	Principal	Secondary	501-1,000	over 10 years
9	S9	Principal	Secondary	501-1,000	over 10 years
10	S10	Deputy Principal	Secondary	501-1,000	over 10 years
11	S11	Deputy Principal	Secondary	over 2,000	over 10 years
12	S12	Business Manager	Secondary	1,001-2,000	over 10 years
13	S13	Business Manager	Secondary	over 2,000	2-5 years
14	S14	Business Manager	Secondary	1,001-2,000	over 10 years
15	S15	Property Manager	Secondary	1,001-2,000	over 10 years
16	S16	Principal	Secondary	501-1000	over 10 years

4.3.2 Organisational structure in PMMS

In the second part of the interviews, the interviewees were asked about the current property and maintenance management process at their schools, starting from the people involved in the process, their roles, and their responsibilities in each process. PMMS requires the collaboration between MoE, schools, and external consultants as shown in Figure 4.2.

The MoE sits at the top of the hierarchy as it assumes a leadership and management role in the delivery of PMMS. The MoE provides policy initiatives, a regulatory environment, and funding for PMMS. There is a property board at the Ministry to organise and maintain the property management system, including

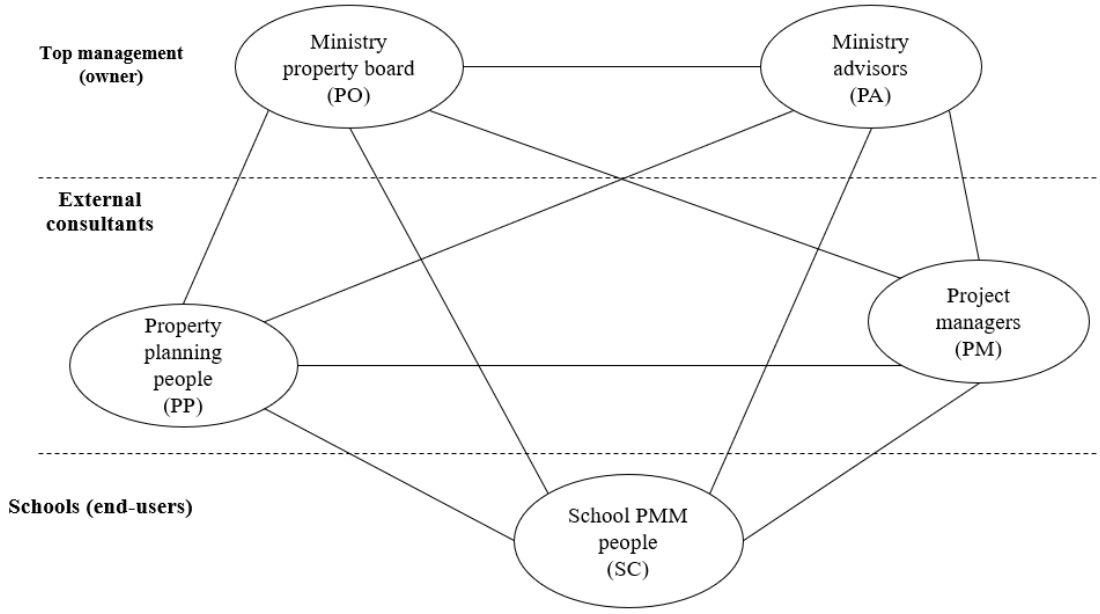


Figure 4.2: Key stakeholders in PMMS

information management, monitoring processes, training, and communication. PA are based in regional offices and their job is to help schools manage their property matters. They serve as an intermediary between the top management and schools and they help implement the long-term property strategy from the MoE to schools and collect feedback in return.

Property planners (PP) and project managers (PM) are external consultants who are pre-approved by the MoE to assist schools in developing property plans and implementing property projects. PP engage with SC to prepare the 10YPP and PM are employed to help schools manage the approved projects in the 10YPP. Schools can employ PM to deliver a specific project or offer them a fixed term contract to deliver projects. School boards, with advice from PA, PP, and PM, decide themselves how to use the PMG to maintain their properties. In-depth discussions were held during the interviews to investigate the current processes in PMMS including specific responsibilities of PO, PA, PP, PM, and SC in PMMS.

All participants in the interviews agreed that although the roles were clearly defined, staff differed with regard to how they executed their tasks. Having the right people is very important as this idea mentioned by ten interviewees. Explaining the above, two interviewees from reported:

"...They have got too much staff turnover. We've had eight different property advisors in the ministry in the last 10 years. And I can say too many of them

don't have enough experience in the industry. ..." (S11).

"...I think it would be helpful if you had expert people who were doing an annual inspection of schools and identifying what is urgent. There can be great variation between MOE people, PP, and PM..." (S12).

"...MoE should have qualified people who understand the process and make right decisions for the maintenance. Principals are not experts in maintenance...' (P2).

Therefore, the interviews were followed with sub-questions about the current processes in PMMS with specific tasks and responsibilities of the people involved in PMMS and how they perform their tasks and work together to achieve the defined objectives.

4.3.3 Current processes in PMMS

The information provided by the participants indicates that the schools involved in the interviews were following the same processes. The participants provided similar information relating to processes in PMMS as the researcher obtained from field trips and interviews in the preliminary study. The processes of managing property in state schools currently has two stages: Planning and Implementation.

4.3.3.1 Planning

All participants described a similar process for planning in PMMS. In the planning phase of PMMS, those responsible aim to develop a 10-year long-term property plan (10-year property plan-10YPP). The primary aim of the 10YPP is to prioritise property projects and maintenance work for the next 10 years. Before the 10YPP process, the MoE appoints external 10YPP consultants (PP) from the 10YPP consultant panel to support schools in developing the 10YPP. Based on the information gained from the interviews, the PP are responsible for completing the school Condition Assessment and preparing the 10YPP.

As explained, SC use their school charters (goals and strategies for the school development), condition assessment data, and other inputs to inform the 10YPP. School boards provide for the needs of their school's teaching practice and for their community. They also deliver up-to-date information on their school site, buildings, and services such as heating, plumbing and electrical systems, and other information required for the 10YPP development.

The usual process of developing the 10YPP as described by the participants in the interviews looks like this: PP coordinates with SC to review the history of property projects and specialist reports and then conducts a condition assessment to identify all property matters that will need to be addressed in the next 10 years. Subsequently, the PP prioritises the projects for the 5YA and estimates the budget required. The PP needs to ensure that preparing 10YPP complies with the guidelines and MoE requirements. Once the school board is satisfied with the 10YPP, the PP submits the plan to MoE for approval. The MoE checks and approves the 10YPP if it meets the policy and funding criteria. Once MoE has approved the 10YPP, the 5YA is signed and the budget is released for the school to implement the approved projects.

The outcomes of the planning stage depend largely on the collaboration between the PP and the school with the support of PA as *"basically PP will lead the process. Once the 5YA grant has been agreed by the Ministry, we have an advisor in the Ministry to tell us what is possible, what's not possible for the projects"* (S9), but *"no one knows what the issues are and what the school needs better than the school board"* (S14). P4, P5 and S12 agreed with the above comment. The findings from the preliminary study also confirm that the output of the planning stage is influenced by the collaboration of PA, PP and SC.

In term of budgeting and developing a cost plan for maintenance, the 5YA budget is included in the 10YPP, and PMG is allocated according to the system of the MoE. Once schools receive the budget, SC have to decide which maintenance tasks need to be done this year and which can be carried over to following years. All schools in the interviews indicated they used historical information and school board members' experience to plan and schedule maintenance tasks within the allocated budget. All respondents also confirmed that they do not use a standard estimation method or the national bench-marking system for developing the cost plan for maintenance. Instead, as P9 reported, *"the annual budget for maintenance is based really on historical information, what we get from the quotes of contractors and what we have to spend"*. However, 12 of 13 respondents agreed that the PMG was not enough for their schools' needs. P3 pointed out the issue, saying that *"you can identify tasks but actually you haven't got the resource or the finance to do these tasks, it is the problem"*.

4.3.3.2 Implementation

All schools in this study engage with external project managers (PM) to assist them in managing the projects in their 5YA to comply with MoE requirements. PM coordinate with SC to match the projects in their 5YA with other school activities. Then, the procurement is processed to first select contractors and then implement the work package. PM are responsible for managing project delivery, communication and information sharing, problem-solving and dispute management. Schools employ PM from a list of project managers pre-selected by MoE. During the interviews, four participants expressed dissatisfaction with the projects managed by a PM recently in their schools. This can be illustrated by the following statement made by P1: *"...the school historically has had a lot of problems with project management of 5YA projects and had a really bad deal..."*

Other comments on this matter included P8, who stated that their school experienced a delay in their 5YA projects. P9 and P4 also pointed out that the lead contractor and subcontractors did not know the schools' operation so they did not design the projects properly.

Regarding maintenance work, school boards decide how to use the PMG for building and property maintenance (painting, minor repairing, minor replacements, or site maintenance). Except for urgent repairs listed in the MoE guide (repairs for damaged stairs, railings, cracking around ceiling beams or foundation, live electrical, mains gas, sewerage or water issues, soil liquefaction, and building movement off piles), maintenance work is prioritised alongside with 5YA programmes to maximise the effectiveness of a sequence of work. Then, maintenance contractors are selected to perform a certain work.

4.3.3.3 Responsibilities in PMMS

Based on current processes and roles of the people involved in PMMS provided during the main interviews and findings in the literature review, responsibilities of each group stakeholders involved in PMMS are categorised in Table 4.2, 4.3, 4.4, and 4.5. Responsibilities of top management have been discussed in several studies. Top management of organisations usually is responsible for developing and establishing strategy and policies for managing their assets (Hackman, 2008; Hastings, 2010; ISO 55000, 2014; PAS 55, 2008*b*). In PMMS, PO has the highest responsibility, therefore, PO has responsibilities to establish a long-term strategy (PO1) and also provide policies (PO2) for delivery of PMMS including funding

allocation (PO7) (Queensland Government, 2017). These responsibilities were confirmed during the interviews with school managers.

On the other hand, roles and responsibilities of people involved in the process are also assigned by top management of organisations (PO4), (Hastings, 2010; ISO 55000, 2014; Queensland Government, 2017). In addition, top management ensures that employees are aware and competent by providing appropriate training and education (PO5) (ISO 55000, 2014). Top management should recognise the need and establish protocols to improve communication (PO3) and interaction across organisations (ISO 55000, 2014; Lifetime Reality Solution, 2014; PAS 55, 2008*b*). Organisation should evaluate of performance of their asset management system against the predefined objectives. Therefore, top management should establish a performance evaluation framework (PO6), which indicates what needs to be measured, how to measure and when the measuring shall be performed (Hackman, 2008; ISO 55000, 2014; PAS 55, 2008*b*; Queensland Government, 2017). It is also advised that top management should review the asset management system (PO9), and make changes to the asset management system, if necessary (ISO 55000, 2014). However, PO5, PO6, PO8, PO9, and PO10 were not mentioned by school managers during the interviews.

Regarding responsibilities of others, ISO 55000 (2014) state that anyone involved in asset management should understand their roles and authorities assigned by the top management (PA1, PP1, PM1, SC1). As described in Section 4.3.3, and Figure 2.12, a breakdown of responsibilities of PA, PP, PM and SC regarding planning and implementing property projects is listed (PA2, PA3, PA4, PA5, PP2, PP3, PP4, PP5, PM2, PM3, PM4, PM5, SC3, SC3, SC4, SC5, SC6, SC7, SC8). Other responsibilities of PA, PP, PM and SC have not mentioned by the interviews' participants (PA6, PA7, SC9), but are explored from the literature review.

Rahmat and Ali (2010) and Newig et al. (2008) agree that monitoring performance ensures that processes have been carried out as planned and that the outcomes meet the stakeholders' expectations (PA7, SC4). Meanwhile, accurate and updated information about the property condition (PP5, SC8, PM5) and its performance enable managers to make informed and practical decisions in the planning stage ISO 55000 (2014); Kelly et al. (2005). The information collected in the monitoring and evaluation processes serve to generate lessons (PA6, SC9) to improve the effectiveness of the management.

Table 4.2: Ministry property board's responsibilities

Code	**Ministry Property Board**	**Literature review sources**	**Interviews' findings**
PO1	Developing long-term strategies for PMMS	Hackman (2008); Hastings (2010); ISO 55000 (2014); PAS 55 (2008*b*)	Yes
PO2	Providing policies for delivery of PMMS	Hackman (2008); Hastings (2010); ISO 55000 (2014); PAS 55 (2008*b*)	Yes
PO3	Providing communication protocols for people involved in PMMS	ISO 55000 (2014); Lifetime Reality Solution (2014); PAS 55 (2008*b*)	Yes
PO4	Defining roles and responsibilities of all people involved in PMMS	Hastings (2010); ISO 55000 (2014); Queensland Government (2017)	Yes
PO5	Providing training programs for people involved in PMMS	ISO 55000 (2014)	Yes
PO6	Establishing a performance evaluation framework for PMMS	Hackman (2008); ISO 55000 (2014); PAS 55 (2008*b*); Queensland Government (2017)	Not mentioned
PO7	Calculating and paying funding for PMMS	Queensland Government (2017)	Yes
PO8	Establishing a reporting system for collecting required information	ISO 55000 (2014); Queensland Government (2017)	Not mentioned
PO9	Reviewing the current system against the long-term strategy	ISO 55000 (2014)	Not mentioned
PO10	Enhancing improvement actions for better delivery of PMMS	ISO 55000 (2014)	Not mentioned

Table 4.3: Ministry advisors' responsibilities

Code	**Ministry advisors**	**Literature review sources**	**Interviews' findings**
PA1	Understanding their roles and responsibilities in PMMS	ISO 55000 (2014)	Yes
PA2	Co-ordinating completion of 10YPP for schools	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PA3	Supporting schools to complete their property plans	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PA4	Connecting schools to MoE	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PA5	Monitoring the school property projects	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PA6	Sharing knowledge and lessons to help schools resolve property issues	ISO 55000 (2014)	Not mentioned
PA7	Helping schools improve their property maintenance outcomes	Controller and Auditor (2017); Ministry of Education (2017)	Not mentioned

Table 4.4: External consultants' responsibilities

Code	**Property Planners**	**Literature review sources**	**Interviews' findings**
PP1	Understanding their roles and authorities in PMMS	ISO 55000 (2014)	Yes
PP2	Conducting condition assessments	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PP3	Preparing 10YPP	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PP4	Estimating the required funds for the plan	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PP5	Ensuring required information is updated in the MoE's property condition database and shared with schools	Controller and Auditor (2017); Ministry of Education (2017)	Yes
Code	**Property Managers**		
PM1	Understanding their roles and responsibilities in PMMS	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PM2	Selecting appropriate contractors for the approved projects	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PM3	Ensuring project implementation in an effective and timely way	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PM4	Helping schools prioritise maintenance tasks for the facility	Controller and Auditor (2017); Ministry of Education (2017)	Yes
PM5	Ensuring required information is updated in the MoE property database and shared with schools	Controller and Auditor (2017); Ministry of Education (2017)	Yes

Table 4.5: School boards' responsibilities

Code	**School boards**	**Literature review sources**	**Interviews' findings**
SC1	Understanding their roles and responsibilities in PMMS	ISO 55000 (2014)	Yes
SC2	Understand staff and students' needs for school buildings and infrastructure	ISO 55000 (2014)	Yes
SC3	Ensuring property projects align with school activities and objectives	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC4	Ensuring that maintenance management at the school complies with legal and MoE requirements	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC5	Engaging with PP and PA to prepare 10YPP	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC6	Ensuring day-to-day maintenance of school property	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC7	Ensuring their school follows the approved property plan	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC8	Recording and updating information for PMMS	Controller and Auditor (2017); Ministry of Education (2017)	Yes
SC9	Collecting and sharing lessons for improvement of PMMS	ISO 55000 (2014)	Not mentioned

4.3.4 Challenges in PMMS

Part 3 of the interviews was conducted to investigate the participants' perspectives on the issues and challenges which prevent the achievement of the long-term strategy of PMMS. The respondents listed various issues and challenges that their schools have experienced. Common challenges can be grouped as below:

4.3.4.1 Lack of a shared vision

Participants commented on the differences in priorities between the MoE, external consultants, and schools in relation to property and maintenance management at schools. Six participants complained about lack of maintainability consideration due to inappropriate designs of the MoE-lead projects at their schools. P4, S10, S12, and S14 stated that maintainability had been neglected during the design and construction stage, resulting in difficulties in maintenance operations and extra cost for their schools. P4 and S10 also felt that the design contractors used the same layout and design for schools despite differences in setting and context in these schools. This may lead to difficulties in maintenance for some schools.

Regarding school-lead projects, the success of property and maintenance management relies on the experience of and communication between PA, PP, PM, and SC. In the planning phase, PP are not on-site staff, so they hardly understand the daily characteristics and operations of school buildings and end-users' requirements. Ten participants raised the issue as they found the long-term plans that PP developed for their schools were not appropriate, especially in terms of the projects' budget. They felt that the plan and projects tend to be aimed at achieving cost effectiveness rather than long-term goals. In the Implement phase, sometimes the PA and PM had different priorities, which confused the school boards. S13 provided an example of the communication issue:

"...my project manager and ministry advisor do not work well together around property projects. This makes difficult conversations when trying to move forward with projects, and the two will not sit in the same room. Each gives me separate advice, and I am then required to work backwards and forwards between them...".

PMMS is naturally complicated as a result of the complicated relationships of stakeholders. There may also be a lack of understanding and knowledge of school managers, especially in primary schools, because most of school principals and boards are not specialist in property and maintenance management.

"...as a beginner principal dealing with the whole management of the school

and then property on top has been a very hard task, and I have just survived the year and paid very little attention to the property, being very reliant on the experts around me and putting trust in their knowledge..." (P3).

However, external consultants perform specific and short-term tasks/projects. While external consultants manage to achieve the common goals of the projects, there may be conflicts between their organisational goals with the long-term goals of PMMS, which prevents a shared vision for the projects. Furthermore, although the tasks may be completed, external consultants' decisions and actions still impact subsequent tasks, but at which point the external consultants are no longer involved. This can lead to problems and difficulties in ultimately optimising the PMMS at that school. The shared vision of collaboration of participants in PMMS should not only focus on a specific task, but also consider objectives over the entire life cycle of properties.

Another concern has been noted during the interview is although all schools have to follow the Ministry's processes and guidelines for funding of the PMMS, schools may have their own way of using the property maintenance grant (PMG). The PMG is a part of the operational grant, and schools receive it yearly, so they put aside a certain amount of money for cyclical maintenance (mainly exterior painting) each year, and after 7 to 10 years they can use the money for the painting. However, S15, S9, P1 reported that *"PMG do not have enough for that"*. P2 reported that *"some schools just use money in PMG which needs to be set aside for painting or other work in future years for reactive or other things such as learning..."*. P5 and P9 mentioned that most of the PMG at their school was used for their care-takers' wages and ground maintenance, and *"it usually exceeds the amount of money that we get for PMG"* (S9). Due to the maintenance funding is spent on other purposes, the deferral of maintenance will occur reducing quality of properties.

4.3.4.2 Imbalance of Resources

Funding mechanisms and streams for PMMS are a common issue listed by both primary and secondary schools in this study. Eight participants mentioned that the maintenance of the school property is not effective due to inappropriate existing formula-based funding model. The current funding system is based on the number of students enrolled and the size of buildings, so it has not been adjusted to meet the schools' needs. P4 commented that *"the allocation of funding is not*

equitable. Lack of upgrading continues in old schools, and the money is not sufficient to bring the property in old schools up to required standards". Schools often have to add other sources for the PMG such as extra income from international student fees, and fundraising from the community. However, this is not a suitable way for keeping the properties safe and well. *"...well an example in 2016, there were toilet blocks needed new flooring and we could have waited another 12 months and put it onto our 5YA. Then we didn't want to wait one more year so we just paid for it ourselves..."* (P2).

"..school board increasingly has to look to their fundraising to cover the work that the 5YA does not cover. The estimate and the real cost do not meet..." (P5).

This problem may be even more pronounced for schools in isolated locations due to lack of service providers and travel cost, as S10 pointed out:

"...we are located in an isolated environment, and it costs a lot just to get a plumber or builder to come and look at a job - then they have to get parts up from the city, we had to pay travel cost and travel time in addition to the job itself...". In term of the 5YA funding, although the budget is estimated based on the condition assessment and actual needs of schools, issues of using this fund still exist. Schools sometimes have to use the PMG for 5YA, and then need to use other fund for maintenance, leading to an imbalance of funding for regular maintenance. The issue was mentioned by: *"...because for years here we were spending property maintenance money fixing leaky roofs and find money to replace the roof. So we spent a lot of money maintaining this, while the roof actually would be 5YA to replace years ago, but it just didn't happen..."* (S8).

"...schools are not funded sufficiently for property maintenance, so we are taking money from the money that's been allocated to the school for teaching and learning programs to maintain property. My personal view is we wouldn't be able to maintain the school on what the Ministry gives us..." (S9).

Although schools can apply for more fund for the additional cost and a maximum of 50% of the budget allocated can remain available for two further years, the preventive and condition-based maintenance plan have not implemented successfully. Two participants said that "it usually takes months or years for the extra fund to be provided". It may cause delay of the project and influence overall the maintenance programme.

4.3.4.3 Lack of capability

Primary school managers in the interviews did not have qualifications from or a background in the property and maintenance management field. In addition, all the primary principals in the interviews pointed out that they do not have enough time for property matters due to it involves a lot of time consuming tasks and all primary school managers in the research pointed out that this is the most pressing management task. P5 claimed that *"dealing with property matter is the burden on our school board*, while P1 stated that *"it would be great for school boards if maintenance management can be centrally managed by regional agency or the Ministry"*. Therefore, in existing model, the success of the property projects and maintenance management depends largely on the capability of external consultants, and according to P4, *"there is lack of competent and qualified property planners and project managers"*. Not only P4 mentioned this challenges, S8, S10 and S15 agreed that a lack of capabilities of PA, PP and PM is one of the main barriers for effective management of school property.

Another concern that the participants raised in the interviews is the accuracy of the estimated cost of the projects in comparison with the actual cost. The budget estimation is leaded and calculated by PP with the assistance of PA and SC. Nine participants agreed that the estimation should cover the annual increase in prices over the five years. P9 provided an example as *"we only were able to complete two-third of our plan because price rises took up the other one-third of the budget"*. The budget and resourcing constraints lead to *"half-solution"* (S9) that create more problems for PMMS. The funding has not been adjusted to reflect the increased costs associated with the school's context. Therefore, not all 5YA projects have been implemented as identified and only some projects have been completed in the scheduled years. Consequence, failure may occur, and it will increase the reactive and corrective maintenance cost and total maintenance cost as well. It can be understood that why 60%-80% of the PMG were used for reactive maintenance in the schools. The poor of estimating and planning processes may result to problems in maintenance implementation and lead to failure of the optimal use of the maintenance budget.

During the interviews, the participants expressed that their schools try to schedule their maintenance tasks at suitable times, which is usually in school holidays to avoid interrupting school life. However, as P1 pointed out, sometimes schools can not find a PM for 5YA projects or local service providers for the

maintenance tasks during their breaks, as it has become a peak season for them. Another issue in human resources is a frequent turnover of some key participants. The MoE advisor staff changes regularly as S14 and S11 have been working with many MoE advisor staff over the years. These changes cause projects to slow down since it takes time for the new staff to understand the schools' context and property conditions to provide valuable advice.

4.3.4.4 Lack of information management

PA, PM, PP, and SC are working together to manage buildings and infrastructure of state schools. The key parties, however, are based at different locations and offices, and PMMS is considered the fragmented process, which requires an effective information management and exchange to ensure the information needed is kept up to date and accurate. However, eleven participants reported experiencing difficulties in exchanging information with external consultants and PA.

The information is usually kept in reports of PP, PM and, and contractors. S11 pointed out a high turn-over of PA and external consultants leads to the loss of both explicit and tacit knowledge as there is no formal feedback collection among the stakeholders. At the school level, maintenance data is updated by reports, emails, and verbally in meetings which is then documented manually. Only S11's school has been using a computerised property data-base, 12 other schools have not used a standard system for information management of maintenance issues and tasks. There is a lack of policies, tools and procedures from MoE supporting for information management at the school level.

For 5YA projects a centralised condition assessment system was developed to collect data on the condition of school properties. The system is operated and managed by the MoE. P5 mentioned during the interview that *"you can see how much is being spent in the system, we can show these are the projects that have been completed and what is still on hold"*. This system, theoretically, provides both schools and the Ministry with information of the property status and cost of maintaining the property on a school by school basis. However, it is only designed to monitor the budget; the information and feedback from schools on completed projects has not been collected, so that lessons can not be shared. The property needs of schools are not well considered because of the lack of information management.

4.3.4.5 Lack of performance evaluation

The respondents were asked about how project performance was evaluated once a project had been completed. All respondents stated that their schools observe and measure the performance mainly based on maintenance reports submitted by the contractors as "no one in our school does the task as we have no expertise", P3 stated. Half of the participants addressed that feedback and report system are not effective and that there had been no significant improvement after submitting their feedback and reports to the MoE in the past. *"No post-evaluation or back-up support"* was the experience of P1 and S11. The feedback loop between the schools and the MoE is currently inactive as the review of current 5YA projects will be done after year three and mainly monitor the funding allocated. Because knowledge sharing and improvement is essential for any organisation to achieve success. Since there is no systematic evaluation of project performance and achievement of the long-term plans, corrective, reactive, and improvement actions are hardly implemented in property and maintenance management of the school property.

4.3.5 Research hypotheses

Findings from the preliminary study and interviews provide an in depth understanding of the organisational structure and current processes in PMMS. It is expected that individuals have an understanding of their roles and responsibilities in PMMS and have specialist knowledge and expertise that can contribute to the achievement of common goals. With the way people are organised, successful PMMS requires the active participation of people from different functions and disciplines to work closely. However, the interviews' findings reveal critical issues in PMMS due to the current organisational structure, policies, and processes. In order to solve the problems, there is a need to explore the relationships between the activities in PMMS, how key stakeholders currently work together, and how they affect each other in order to perform their roles effectively.

These findings are line with Ampofo et al. (2020) and Au-Yong et al. (2017) who indicated that key stakeholders all have specific roles and tasks to perform at different stages of the building maintenance and property management cycle. Other researchers argued that relationships among the key stakeholders affect the outcome of the management (Ampofo et al., 2020; Hackman, 2008). When

the key stakeholders work collaboratively, it will result in better outcomes as decision-makers can be informed by experienced consultants and users to develop proper plans and avoid repeating mistakes (Queensland Government, 2017).

The study hypothesised that the performance of the stakeholders influences one another and thereby contributes to the overall performance of PMMS. This hypothesis is supported by Aragonés-Beltrán et al. (2017) and (Au-Yong et al., 2017) who have proven that there is a significant relationship between key stakeholders' involvement and maintenance performance. The maturity model framework has been widely adopted in assessing relationships of stakeholders in business processes (Meng et al., 2011). Later, Gimenez et al. (2017) established a maturity model that captures the involvement of stakeholders in order to develop a path for evolution of city resilience building process. Most recently, (Santos et al., 2021) also introduced a maturity model for the supply chain strategy in order to improve the capabilities of the supply chain management process. This literature review of existing models concludes that maturity model frameworks can be adopted to assess maturity level in PMMS and examine the relationships of the key stakeholders who perform the tasks in PMMS.

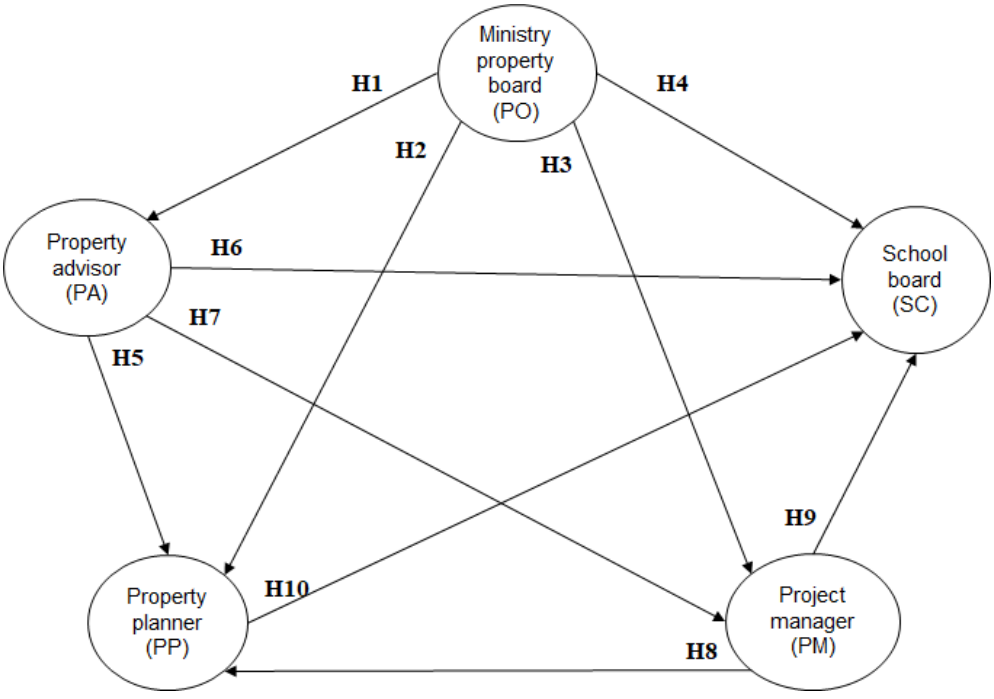


Figure 4.3: Research hypotheses

Figure 4.3 illustrates the hypotheses for this study. As PO has the highest

responsibility for PMMS, it was hypothesised that PO influences all other stakeholders. Similarly, PA works as the advisor staff dealing with all requirements from school and external consultants, so PA are considered to impact the maturity level of responsibilities performed by PP, PM, and SC. Since PM is responsible for implementation of the approved property projects and for recording interventions of school buildings and infrastructure, it is hypothesised that PM affect the performance of PP and SC. Finally, PP, are believed to impact on the maturity level of SC.

4.4 Summary

This chapter presented the findings of the preliminary study, and the main interviews. The preliminary study equipped the researcher with current processes of PMMS, while the interview results highlighted the organisational structure and responsibilities of the key stakeholders in PMMS. The most pressing challenges in PMMS also identified from the interviews are lack of collaboration among the key stakeholders, lack of resources including funding, and human resource, and lack of performance evaluation and information management. Based on findings from the interviews, a model to evaluate the responsibilities and examine the relationships among the key stakeholders in PMMS was proposed in order to investigate the most needed areas for addressing the challenges.

Chapter 5

Maturity Level and Improvement Action Analysis

5.1 Introduction

Chapter 5 describes the analysis of quantitative data collected by the questionnaire to assess the maturity level of current processes in PMMS and test the hypotheses based on the findings presented in Chapter 4. Research hypotheses are proposed and tested using PSL-SEM. The first section presents demographic information of the participants, which help to understand the characteristics of the respondents. Later, the model development and questionnaire delivery are described. This is followed by the results of quantitative data analysis are discussed to identify the maturity levels of activities in the PMMS and the high priority areas for improvement. Finally, evaluations of measurement model and structural model results are examined individually with a conclusion of the research hypotheses.

5.2 Demographic information

There were 185 responses with 18 responses leaving parts of the questionnaire unfinished, 19 responses where only one part of the questionnaire was completed, and 148 answered all questions. As stated in Section 3.5.3.2, the minimum sample for appropriate use for statistical analysis is equal to or greater than 10 times the number of structural paths directed at a particular construct in the structural model (in this study 40), and should not be fewer than 91 observations.

Therefore, the response rates were considered satisfactory and representative of the whole population of this study. Among the 140 SC, 107 participants were working in primary schools and 33 respondents were from secondary schools. Approximately three quarters (73.6%) of the respondents are principals/deputy principals who are responsible for their school's property management matters. Table 5.1 provides a breakdown of the valid responses by respondents' role and school type.

Table 5.1: Respondents' Job Title

Role	**Primary school**	**Secondary school**	**Total**	**Percentage**
Principal/Deputy Principal	91	18	109	73.6%
Property manager/Business manager	5	6	11	7.4%
School board member/School executive officer	11	9	20	13.5%
Ministry advisor			8	5.5%
Total	107	33	148	100%

Table 5.2 presents the number of years of experience respondent have had with the PMMS. 45.3% of respondents had over 10 years working in this field. Principals/ Deputy principals comprised the majority of the respondents who had over 10 years of experience (55/67). Nevertheless, it was clear that some respondents with other job titles also had over ten years experience, particularly school board members and executive officers. Approximately 70% of respondents had been in the field for over five years. This level of experience meant that their responses to the questionnaire could be considered reasonably reliable.

Table 5.3 presents the locations of the schools involved in the study using the four groups established by the Ministry of Education: main urban, minor urban, secondary urban and rural areas. The survey revealed that 53.6% of the schools were situated in main urban areas, 22.1% in rural areas, and 24.3% in minor and secondary urban areas. The table shows that participants from both primary and secondary schools came from all location groups.

Table 5.2: Respondents' year of experience

Role	**Less than 2 years**	**2 to 5 years**	**5 to 10 years**	**Greater than 10 years**	**Total**
Principal/Deputy Principal	10	21	23	55	109
Property manager/Business Manager	3	3	2	3	11
School Board member/School Executive Officer	1	3	8	8	20
Ministry Advisor	1	4	2	1	8
Total	15	31	35	67	148
Percentage	10.1%	20.9%	23.6%	45.3%	100%

Table 5.3: Schools' location

Location	**Primary school**	**Secondary school**	**Total**
Main urban area	60	15	75
Minor urban area	22	5	27
Secondary urban area	2	5	7
Rural area	23	8	31
Total	107	33	140

Table 5.4 indicates the size of the schools based on the number of students enrolled in 2018. 37.1% of the schools had 201-500 students enrolled. Most of the primary schools (81%) had less than 500 students, while in the secondary group, two thirds (66.67%) of the schools had more than 1000 students enrolled. 32.8% account for a group of schools had less than 200 students, most of which were primary schools. In contrast, in the lowest percentage group (1001-2000 students), 13 out of 13 were secondary schools. This is not surprising since there are not any primary school with over 1000 students in NZ in 2018.

Regarding the PA, five participants revealed that they were responsible for property management in between 31 to 50 schools in their region, and three PA had more than 50 schools on their list. The information presented in Table 5.1 to Table 5.4 shows summaries of demographic information of the questionnaire's participants.

Table 5.4: Number of student enrolled in 2018

Number of student	**Primary school**	**Secondary school**	**Total**
Less than 200	45	1	46
201-500	42	10	52
501-1000	20	9	29
1001-2000	0	13	13
Total	107	33	140

5.3 Model development

The primary aim of the quantitative data collection is to examine current maturity level of PMMS and the relationships between the stakeholders involved. For this purposes, the maturity level is measured based on the responsibilities of those involved in PMMS. This allows for the development of clear measurement criteria that are not affected by activities and processes being performed by different people. SC, PO, PA, PM, and PP are constructs or latent variables which are not directly measured or observed but are inferred from the questionnaire indicator scores using factor analysis. Therefore, the five exogenous constructs (presented in Figure 3) were measured to evaluate the overall maturity level of PMMS. The study hypothesised that the performance of the stakeholders influences one another and thereby contributes to the overall performance of PMMS.

The organisational structure in PMMS, as shown in Figure 4.2, will be developed as the structural model. This diagram (or path model) presents connections between variables/constructs based on current theory and logic to visually display the hypotheses that will be tested in this study. According to the findings presented in Chapter 4, there are five constructs (latent variables) in the structural model of this research (PO, PA, PP, PM, SC). The relationships among the constructs are hypothesised and presented as shown in Figure 5.1.

The arrows between two constructs represent the path coefficients, measuring the relative strengths and directions of the partial correlations. There are direct and indirect effects between the constructs. According to Hair Jr et al. (2016), direct effects are established when the two constructs are linked by a single arrow, while indirect effects are represented by multiple arrows and involve a sequence of relationships with at least one intervening construct. An indirect effect is a sequence of two or more direct effects. As shown in Figure 5.1, there are both direct and indirect effects need to be examined when testing the hypotheses.

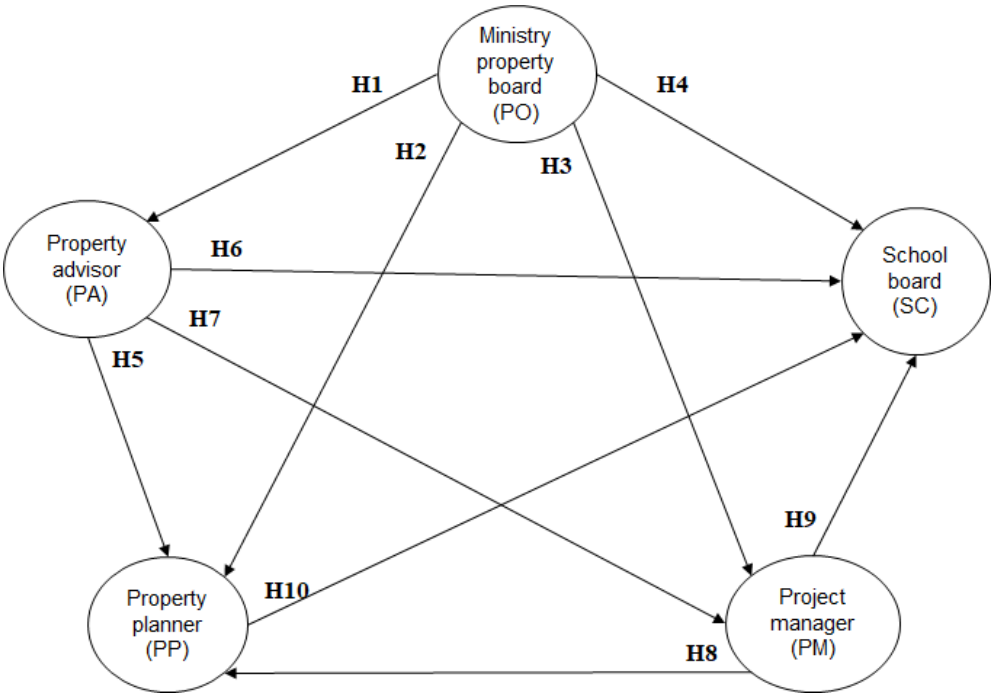


Figure 5.1: Structural model

On the basis of theory and logic, it is known that relationships exist between the constructs, and it is more important to know how the relationships actually works. For example, PO has direct effects on PA, PP, PM and SC; PA directly affects PP, PM and SC. Therefore, PO also has indirect effects on PP, PM, and SC through PA. By examining relationships between the constructs, the researchers should be able to explain how the constructs are related to one another as well as how the maturity level of SC is affected by the maturity level of PO, PA, PP and PM. These constructs or latent variables are not directly measured or observed but are inferred from the maturity level of their indicator variables.

Measurement models explain how these constructs are measured and represent the relationships between constructs and their corresponding indicator variables. Each construct (latent variable) was measured by a combination of indicator variables. In this study, the responsibilities of each party are presented as indicators of the measurement model. According to findings in Chapter 4, indicators for each construct are presented in Table 5.5, Table 5.6, and Table 5.7. The arrows leading out of a latent variable into a cluster of indicators represent a reflective relationship, in which multiple item scores cumulatively. The indicator variables are represented by rectangles and the latent variables are represented by circles,

as shown in Figure 5.3. In this study, the whole model consists of five latent variables (constructs), there are a set of collected data for 36 indicators.

Table 5.5: School board's indicators

Code	**Responsibilities**
SC1	Understanding their roles and responsibilities in PMMS
SC2	Understand staff and students' needs for school buildings and infrastructure
SC3	Ensuring property projects align with school activities and objectives
SC4	Ensuring that maintenance management at the school complies with legal and MoE requirements
SC5	Engaging with PP and PA to prepare 10YPP
SC6	Ensuring day-to-day maintenance of school property
SC7	Ensuring their school follows the approved property plan
SC8	Recording and updating information for PMMS
SC9	Collecting and sharing lessons for improvement of PMMS

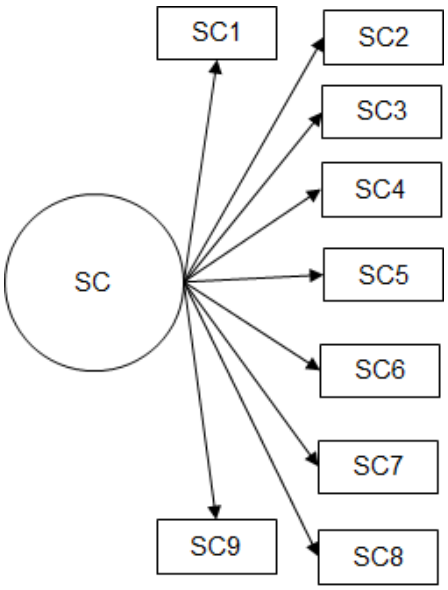


Figure 5.2: SC's indicators

For example, as shown in Figure 5.2, latent variable SC is measured by a combination of indicators (SC1, SC2, SC3, SC4, SC5, SC6, SC7, SC8, S9). Similarly, other latent variables are measured by their indicators and the measurement model is developed as shown in Figure 5.3. Because SC and PA are involved in all stages in PMMS, once the structural model and measurement model are developed, the online questionnaire can be distributed to SC and PA to measure

the maturity level of the constructs. The sample size was explained in Section 3.5.3.

Table 5.6: Top management's indicators

Code	Responsibilities
PO	**Ministry Property Board**
PO1	Developing long-term strategies for PMMS
PO2	Providing policies for delivery of PMMS
PO3	Providing communication protocols for people involved in PMMS
PO4	Defining roles and responsibilities of all people involved in PMMS
PO5	Providing training programs for people involved in PMMS
PO6	Establishing a performance evaluation framework for PMMS
PO7	Calculating and paying funding for PMMS
PO8	Establishing a reporting system for collecting required information
PO9	Reviewing the current system against the long-term strategy
PO10	Enhancing improvement actions for better delivery of PMMS
PA	**Ministry Advisors**
PA1	Understanding their roles and responsibilities in PMMS
PA2	Co-ordinating completion of 10YPP for schools
PA3	Supporting schools to complete their property plans
PA4	Connecting schools to MoE
PA5	Monitoring the school property projects
PA6	Sharing knowledge and lessons to help schools resolve property issues
PA7	Helping schools improve their property maintenance outcomes

Table 5.7: External consultants' indicators

Code	Responsibilities
PP	**Property Planners**
PP1	Understanding their roles and authorities in PMMS
PP2	Conducting condition assessments
PP3	Preparing 10YPP
PP4	Estimating the required funds for the plan
PP5	Ensuring required information is updated in the MoE's property condition database and shared with schools
PM	**Property Managers**
PM1	Understanding their roles and responsibilities in PMMS
PM2	Selecting appropriate contractors for the approved projects
PM3	Ensuring project implementation in an effective and timely way
PM4	Helping schools prioritise maintenance tasks for the facility
PM5	Ensuring required information is updated in the MoE property database and shared with schools

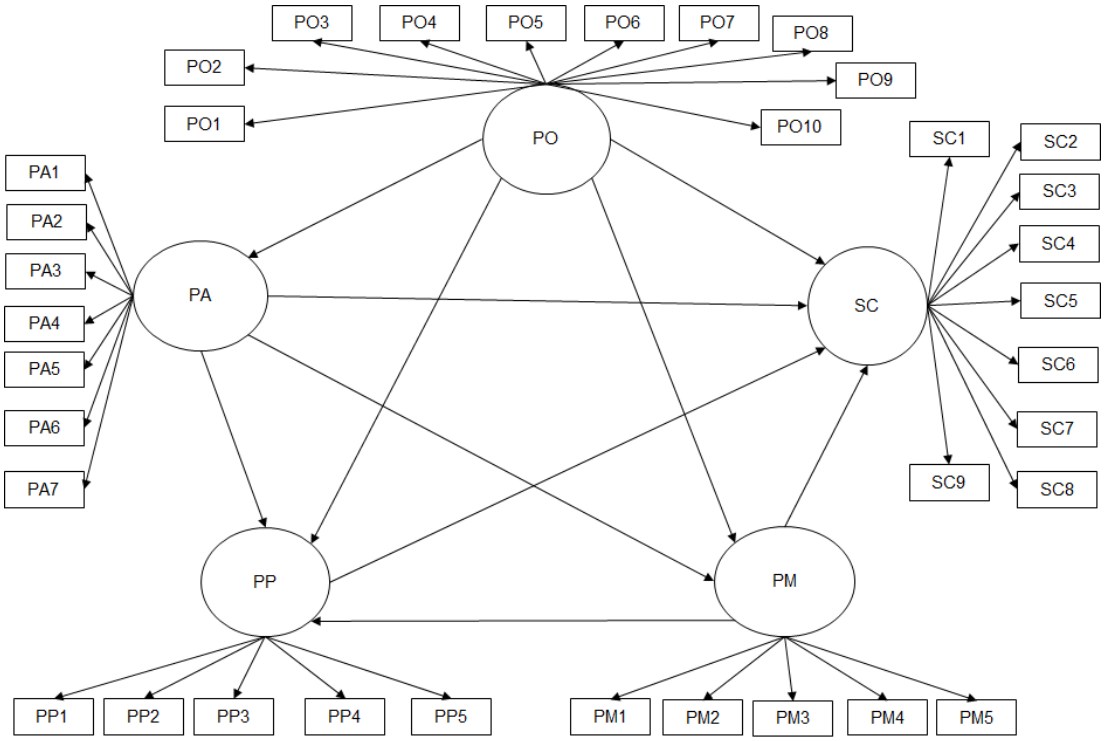


Figure 5.3: Measurement model

5.4 Maturity model for PMMS

The purpose of the questionnaire was to identify the maturity level of elements/activities in the PMMS and examine the relationship between the model variables. Therefore, the first step was to develop a maturity model which was used to assess the constructs' indicators maturity level. Based on literature review of maturity model (Section 2.4), the maturity model used in this study was adapted from the structure, definitions, and distributes of the ISO 55000 assessment model. A maturity scale is associated with a given process. In order to develop a suitable model for the PMMS, a "modified" continuous representation CMM was proposed which also produced a maturity level scale for a single activity in the process. Differently from the original CR terminology, this research prefers to adopt the term "maturity level" instead of "capability level" for a single activity. As presented in Table 5.8 (refer to section 2.4.3 and 3.5.3), there are six levels of maturity in this model. Characteristics of each maturity level were defined to capture the understanding, goals, and resources for each activity of the stakeholders. In order to explore the relationships among the key stakeholders, the process areas for assessment in this study are the performances of five key stakeholders

(PO, PA, PP, PM, SC) and the sub-criteria are their responsibilities in PMMS. Results of the maturity assessment allow the stakeholders to review their current maturity and demonstrate improvement actions to reach higher maturity levels.

The first section of the questionnaire collected demographic data. The participants were asked to provide general background information about themselves and their schools and are presented in Section 5.2. In the second section, the respondents were asked to were asked to evaluated the current maturity level of PMMS. Each question asked the respondents to assess a maturity feature on a scale between Level 0 and Level 5. Based on the answers to the questionnaire, it was then possible to calculate all the maturity indexes of for each element and then for the latent variables. These questions were customised and divided into three categories: MoE and MoE advisors; external consultants (PP and PM); and school property board (SC). The third section consisted of an open-ended question to ask participants about their views and opinions for further improvement of this research.

Table 5.8: Maturity model for PMMS

Level	**Definition**
Level 0: Innocent	This activity is not in place or there is no evidence of commitment to put it in place.
Level 1: Aware	This activity was identified as a need for PMMS and but there is no resource plan to progress it.
Level 2: Developing	There is a resource plan with this activity in place. The goals of this activity have been identified but not satisfied.
Level 3: Competent	The stakeholders involved have a good understanding of this activity. The goals of the this activity have been satisfied.
Level 4: Optimising	The stakeholders involved have a good understanding of this activity. The goals of this activity have been satisfied and its performance has been measured for improvement of PMMS.
Level 5: Excellence	The stakeholders involved focus on continually improving the performance of this activity to deliver the best value for PMMS.

5.5 Findings

5.5.1 Normality of the variables

The normality assumption needs to be considered as it shows whether correct statistical tests have been used for the data set. Many methods exist for testing whether a variable has a normal distribution. Visual methods such as histogram, box-plot, P-P plot and Q-Q plot have been used for checking normality visually (Ghasemi and Zahediasl, 2012).

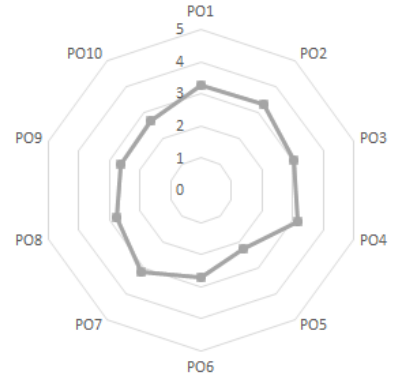
The P-P plot was used to test if the variables in this research are normally distributed. If the data are normally distributed, the result would be a straight diagonal line. Results of the P-P plots (see Appendix A) indicate that the variables are normally distributed and therefore parametric statistics should be used for the data.

5.5.2 Maturity level of PMMS

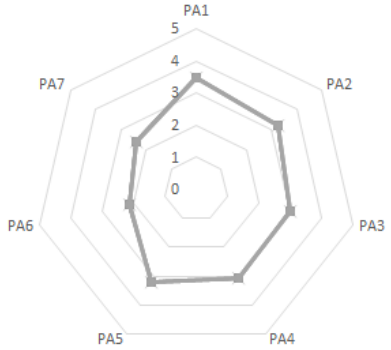
Figure 5.4 presents the maturity level of the indicators and Figure 5.5 illustrates mean scores of each indicator in the measurement model. The maturity level of each construct was calculated by the average of the mean scores of its indicators. The results show that all indicators' mean scores are less than level 4 reflecting that the responsibilities have not been performing effectively and should be improved. As illustrated in Figure 5.4, the respondents evaluated five out of ten of PO's indicators are between level 2 and level 3 (PO5, PO6, PO8, PO9, PO10), indicating that they have been introduced but their goals have not been satisfied. There are also three out of seven PA's indicators which have the maturity level below level 3 (PA3, PA6, PA7).

The results indicate that respondents were satisfied with the performance of SC, PP and PM, with most indicators having mean scores between level 3 and level 4, except PP4 (but almost achieving at level 3), and SC9. This could be interpreted to suggest that PP, PM, and SC have fulfilled their job in PMMS. Based on the maturity level, the weakest points in PMMS have been identified. However, the relationships between the indicators and the constructs and among the constructs should be examined to be able to provide comprehensive recommendations for the improvement of PMMS. PLS-SEM was used to examine the relationships. Further descriptive analysis is followed.

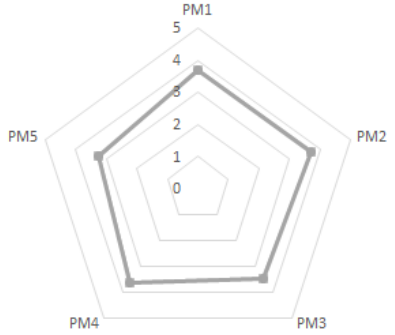
Indicators	Mean	Std.Deviation
PO1	3.28	1.194
PO2	3.32	1.050
PO3	3.05	1.211
PO4	3.16	1.149
PO5	**2.25**	1.228
PO6	**2.70**	1.104
PO7	3.14	1.137
PO8	**2.75**	1.211
PO9	**2.63**	1.252
PO10	**2.66**	1.308
Average	2.89	



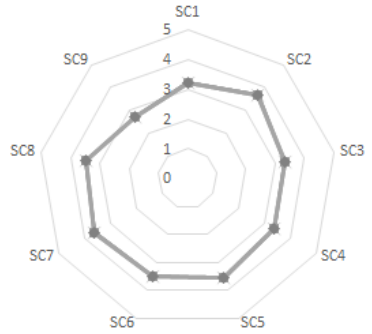
Indicators	Mean	Std.Deviation
PA1	3.49	1.079
PA2	3.23	1.207
PA3	**2.99**	1.317
PA4	3.07	1.297
PA5	3.19	1.225
PA6	**2.14**	1.383
PA7	**2.41**	1.385
Average	2.93	



Indicators	Mean	Std.Deviation
PM1	3.71	1.168
PM2	3.71	1.083
PM3	3.44	1.208
PM4	3.61	1.221
PM5	3.25	1.319
Average	3.41	
PP1	3.51	1.158
PP2	3.28	1.250
PP3	3.34	1.275
PP4	**2.96**	1.360
PP5	3.06	1.213
Average	3.36	



Indicators	Mean	Std.Deviation
SC1	3.24	0.978
SC2	3.68	0.990
SC3	3.32	1.162
SC4	3.36	1.038
SC5	3.55	1.045
SC6	3.48	1.109
SC7	3.61	1.014
SC8	3.48	1.072
SC9	**2.72**	1.365
Average	3.38	



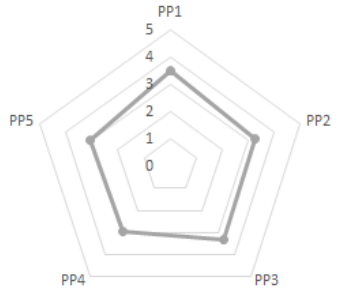


Figure 5.4: Maturity level of indicators

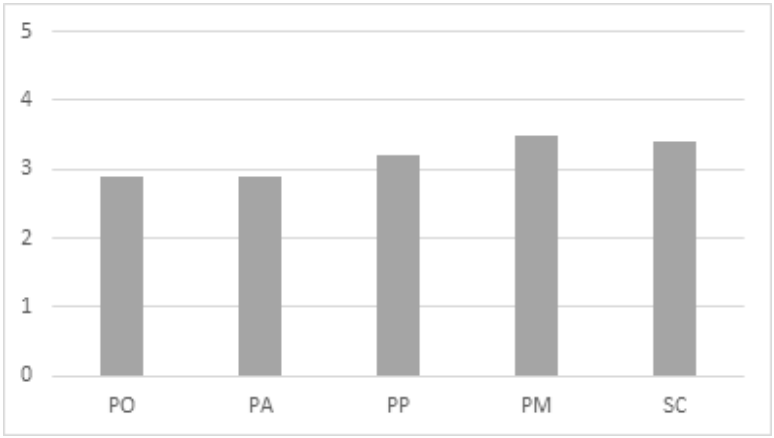


Figure 5.5: Maturity level of PMMS

5.5.2.1 Descriptive analysis for variables

As results presented in Figure 5.4, there are five elements having maturity level scores between Level 3 and Level 4 (PO1, PO2, PO3, PO4, PO7), and the rest between Level 2 and Level 3 (PO5, PO6, PO8, PO9, PO10). The highest mean value was 3.28 (PO1), and the lowest mean value was 2.25 for PO5.

Details of descriptive analysis are presented in Appendix B. The highest agreement rate was 45.3% at level 4 for PO1. Over 10% of the respondents scored PO2, PO3 and PO7 at Level 5. PO5 was the only indicator that more than 5% of the respondents scored at level 0. As shown in Appendix B, the modes were Level 2 for PO5 (34.5%), PO6 (34.5%), PO9 (29.7%), PO10 (27.0%); Level 3 for PO3 (30.4%), PO8 (32.4%); and Level 4 for PO1 (45.3%), PO2 (37.8%), PO4 (34.5%), and PO7 (29.1%). The results suggest that PO1, PO2, PO3, PO4, and PO7 were in place and tended toward Level 4, indicating that the optimisation of the indicators has been achieved. In contrast, PO5, PO6, Po8, PO9 and PO10 were in place but their goals have not been satisfied.

Regarding PA, four indicators had mean scores between Level 3 and Level 4 (PA1, PA2, PA5, PA5), and three indicators had mean scores between Level 2 and Level 3 (PA3, PA6, PA7). The highest mean value was 3.49 (PA1), and the highest agreement rate was 37.2% at level 4 for PA1. More than 10% of the respondents scored Level 5 for all indicators but PA6 and PA7. The lowest mean value was 2.14 for PA6. More than 10% of respondents scored Level 0 for PA6. As shown in Appendix B, the modes were Level 2 for PA6 (25.0%); Level 3 for PA5 (31.1%) and PA7 (28.4%); and Level 4 for PA1 (37.2%), PA2 (31.1%), PA3

(31.8%), and PA4 (30.4%). The results indicate that PA1, PA2, PA4, and PA5 were in place and their goals have been achieved. However, PA6 and PA7 were in high priority for improvement to the next level of maturity.

Most indicators of SC had mean scores between Level 3 and Level 4, except SC9. The highest mean value was 3.68 (SC2), and the highest agreement rate was 44.6% at Level 4 of SC2, SC6, and SC7. More than 10% of the respondents scored Level 5 for each indicator other than SC1 and SC9. The lowest mean value was 2.72 for SC9 (collect and share lesson learnt). No respondent selected Level 0 for SC1, SC4, SC5, and SC7. As shown in Appendix B, the modes for most indicators were Level 4 for SC2 (44.6%), SC3 (37.8%), SC5 (41.9%), SC6 (44.6%), SC7 (44.6%), and SC8 (43.9%); Level 4 for SC1 (37.8%), SC4 (34.5%) and SC7 (29.1%). The results indicate that all indicators except SC9 were in place and their goals have been achieved.

The results indicate that respondents were satisfied with the performance of PP and PM, with most indicators having mean scores between Level 3 and Level 4. The only exception to this is PP4, which almost managed to achieve Level 3. The mode for most indicators except PP5 was Level 4.

5.5.2.2 Comparison between groups of participants

Figure 5.6 provides a summary of the mean scores of the indicators which have a maturity level below Level 3. A maturity level below 3 suggests that the goals of the indicators have not been satisfied. It is not surprising that the assessment of respondents from primary schools are similar to the average scores of the sample since participants from primary schools were the largest group (107/148). Of the indicators, five indicators belong to PO's responsibilities (PO5 - training programme, PO6 - performance evaluation, PO8 - reporting system, PO9 - reviewing, PO10 - improvement); three indicators were responsibilities of PA (PA3 - supporting schools with 5YA, PA6 - sharing lessons, PA7 - helping schools improve their maintenance outcomes); one indicator was the schools' responsibility (SC9 - collecting and sharing lessons); and one indicator was the job of the PP (PP4 - estimating required fund).

Participants from the secondary schools agreed that goals of PO3 (communication), PA2 (co-coordinating of PA for completion of 10YPP) and PA5 (monitoring property projects) had not been satisfied yet as highlighted in Figure 5.6. Meanwhile, PA scored these three indicators greater than Level 3 and tended

Mean Scores of Indicators

Indicators	Average	Primary	Secondary	PA
PA6	**2.14**	2.21	1.79	2.63
PO5	**2.25**	2.34	2.00	2.13
PA7	**2.41**	2.51	2.00	2.75
PO9	**2.63**	2.68	2.33	3.13
PO10	**2.66**	2.72	2.27	3.38
PO6	**2.70**	2.69	2.70	2.75
SC9	**2.72**	2.67	2.97	2.25
PO8	**2.75**	2.81	2.58	2.63
PP4	**2.96**	2.97	3.03	2.50
PA3	**2.99**	3.08	2.42	4.13
PO3	3.05	3.07	**2.91**	3.38
PA2	3.23	3.28	**2.91**	3.88
PA5	3.19	3.26	**2.91**	3.38
SC3	3.32	3.42	3.15	**2.75**
SC4	3.36	3.37	3.48	**2.75**
SC6	3.48	3.50	3.67	**2.50**
SC8	3.48	3.50	3.58	**2.75**

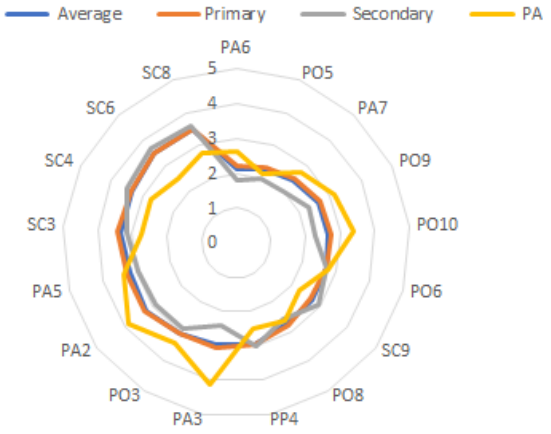


Figure 5.6: Summary maturity level (below Level 3)

toward Level 4 (PA2) but evaluated the four following indicators below Level 3: SC3 (ensuring property projects align with school activities and objectives), SC4 (complying with legal and MoE's requirements for the PMMS), SC6 (ensuring day-to-day maintenance), and SC8 (recording and managing required information for the PMMS).

The comparison of maturity scores reveals that six indicators were evaluated below Level 3 by the two groups: PO5, PO6, PO8, PA6, PA7, and SC9. Participants from schools were not satisfied with PO9 and PO10, while Ministry advisors reported that SC3, SC4, SC5, and SC8 were below Level 3. Respondents from primary schools and Ministry advisors indicated that PP4 was below Level 3;

however, secondary school participants scored PP4 greater than Level 3. Surprisingly, PA3 was scored below Level 3 by secondary school participants (2.42), between Level 3 and Level 4 by primary school respondents (3.08), and greater than Level 4 by Ministry advisors (4.13). A possible explanation for the differences is the variety of abilities of people involved in the activities. The findings have important implications for developing the PMMS framework in Chapter 6.

It can be seen from Figure 5.6 that there are no indicators in the list that capture the project managers' (PM) responsibilities, and only PP4 relates to the responsibilities of property planners. It can be thus suggested that property planners and project managers have fulfilled their job in the PMMS. However, the relationship between the indicators and latent variables as well as the relationships among the latent variables should be examined to provide comprehensive recommendations for the development of the PMMS framework.

5.5.3 Evaluation of PLS-SEM results

SC, PO, PA, PM, and PP are constructs or latent variables which are not directly measured or observed but are inferred from the questionnaire indicator scores using factor analysis. PO has a direct effect on SC and indirect effects which are transferred by PA, PP, and PM. Similarly, PA and PM have both direct and indirect effects on SC, according to the arrow's direction in Figure 5.7. PP has a direct effect on SC.

In this study, partial least squares analysis (PLS-SEM) was used to test the relationships between the indicator variables and the latent variables as well as the relationships among the latent variables included in the hypotheses below and as shown in Figure 5.7. According to Hair Jr et al. (2016), evaluation of PLS-SEM results involves a two-step procedure: measurement model assessment and structural model assessment as presented in Figure 5.8.

The model assessment starts with an evaluation of the measurement model to assess the validity and reliability of the instrument. As stated in Chapter 3, assessing the quality of the measurement model includes:

- Internal consistency reliability (Composite reliability): This measure assesses the inter-correlation between the indicators that are intended to measure the same construct. The traditional criterion for internal consistency is Cronbach's alpha. Cronbach's α has scored in [0,1], and a higher value of

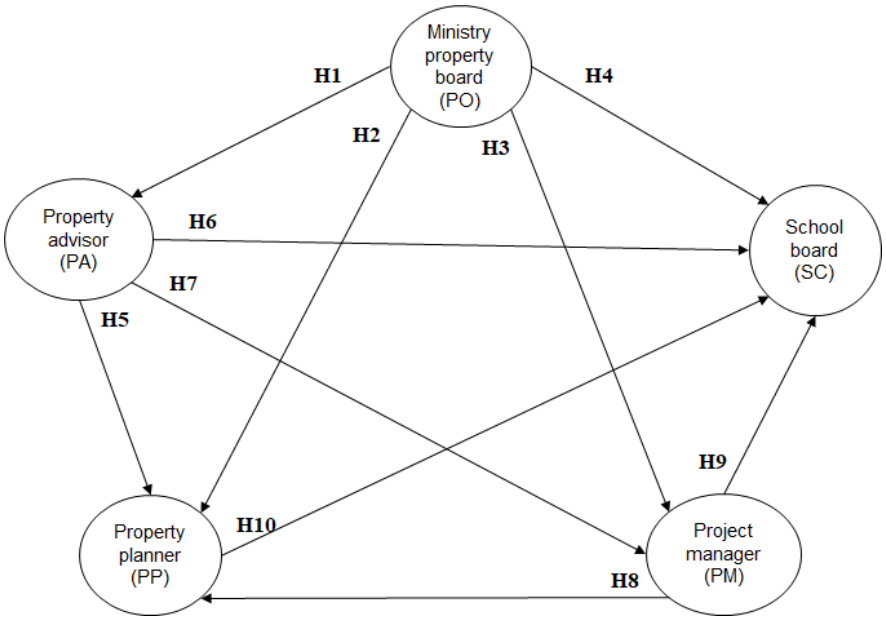


Figure 5.7: Research hypotheses

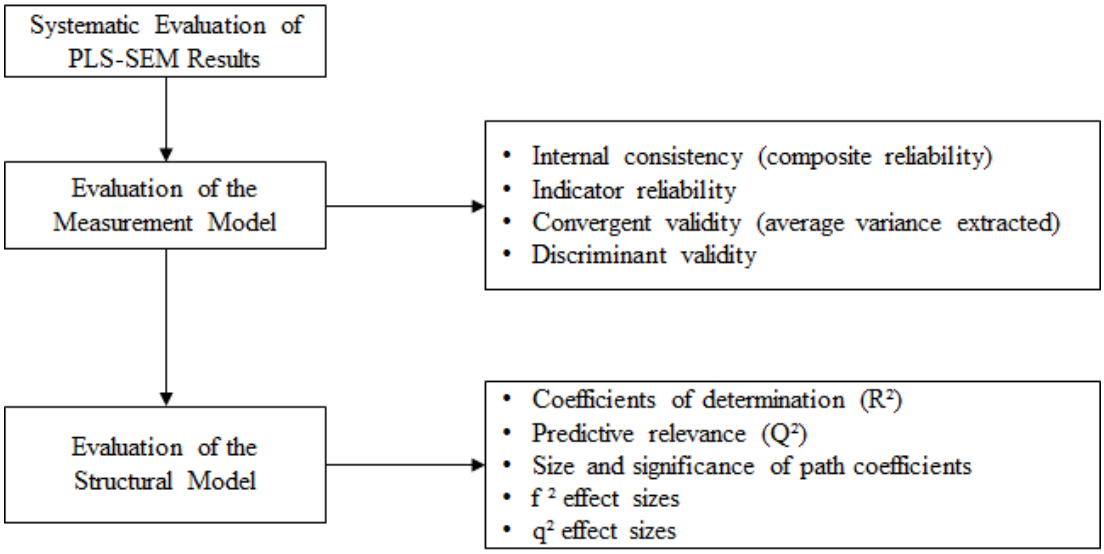


Figure 5.8: Evaluation of PLS-SEM results. Adopted from Hair Jr et al. (2016)

the score means greater reliability of the measurement of the research (but should not be greater than 0.95);

- Indicator reliability: High factor loadings on a construct indicate that the associated indicators have much in common, which is captured by the construct. The indicator's outer loadings should be higher than 0.708. Indicators with factor loadings between 0.40 and 0.708 should be considered for

removal only if the deletion leads to an increase in composite reliability and AVE (see below) above the suggested threshold value;

- Convergent validity: A common measure to establish convergent validity on the construct level is the average variance extracted (AVE). The minimum suggested value of the AVE is 0.5;
- Discriminant validity: The purpose of discriminant validity is to demonstrate that the constructs should be distinct from each other. An indicator's outer loadings on a construct should be higher than all its cross-loadings with other constructs.

Once the reliability and validity of the measurement model have been established, the structural model can be evaluated to provide more advance analyses. Figure 5.9 shows the process used to assess the structural model results. The structural model results provide the model's predictive capabilities and explain the relationships between the constructs.

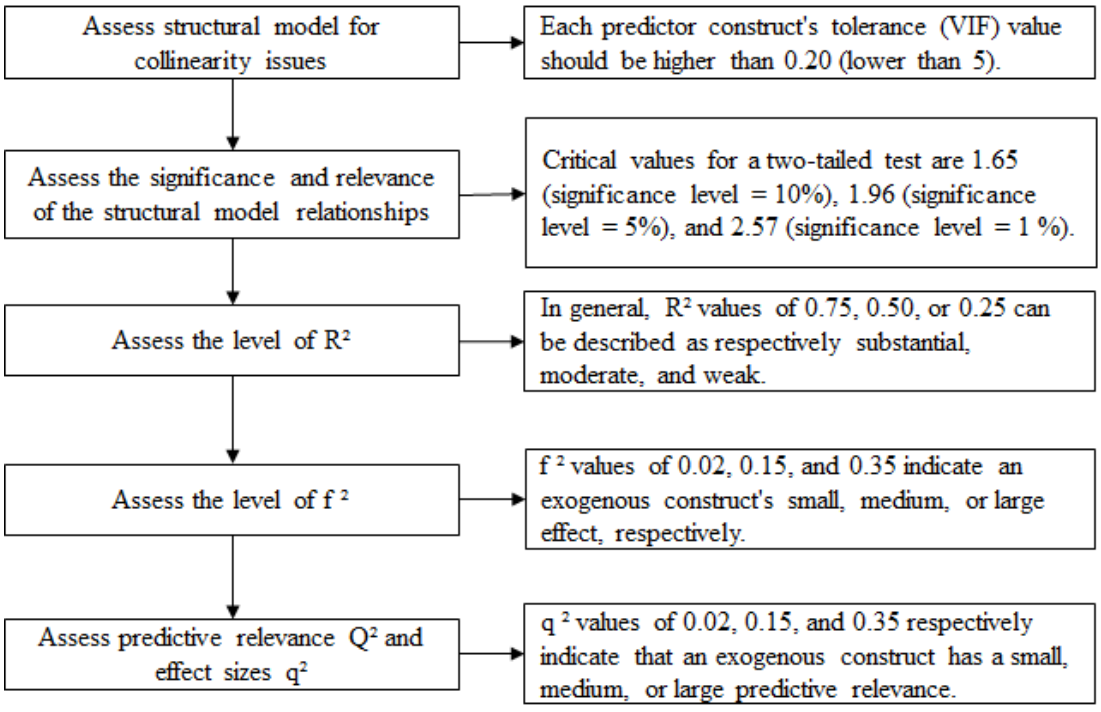


Figure 5.9: Evaluation of the Structural Model. Adopted from Hair Jr et al. (2016)

5.5.4 Evaluation of the measurement model

The model was run by SmartPLS version 3. To correctly estimate a PLS path model, PLS algorithm and parameter settings must be selected to run the algorithm. The basic setting includes selecting the structural model path weighting approach, the stop criterion, and the maximum number of iterations (Hair Jr et al., 2016). There are three structural model weighting schemes: (1) the centroid weighting scheme, (2) the factor weighting scheme, and (3) the path weighting scheme. It is recommended to use the path weighting scheme approach (Dijkstra, 2010). The reason for this selection is that the weighting scheme provides the highest R^2 value for latent variables and is generally applicable for all kinds of PLS path model specifications and estimations.

The PLS-SEM algorithm is designed to run until the results stabilise or until the change in the outer weights between two consecutive iterations is smaller than the stop criterion value (Hair Jr et al., 2016). The maximum number of iterations that will be used for calculating the PLS results should be sufficiently large (for this study 300 iterations), and the stop criterion should be low (for this study 10^{-5}), as recommended by Hair Jr et al. (2016)). When checking the PLS-SEM result, researchers must ensure that the stop criterion of the algorithm was reached and should be lower than the maximum number of iterations. Figure 5.10 shows the PLS-SEM algorithm in this study converged after Iteration 4 (lower than 300). Note that Figure 5.10 displays only a fraction of the results table. The full result table is presented in Table B1, Appendix B.

	PA1	.....	PM1	....	PO1	....	PP1	....	SC1	....
Iteration 0	0.174	0.174	0.226	0.226	0.132	0.132	0.233	0.233	0.141	0.141
Iteration 1	0.155	0.177	0.223	0.226	0.127	0.133	0.226	0.223	0.162	0.124
Iteration 2	0.155	0.177	0.223	0.226	0.128	0.133	0.227	0.222	0.162	0.124
Iteration 3	0.155	0.177	0.223	0.226	0.128	0.133	0.227	0.222	0.162	0.124
Iteration 4	0.155	0.177	0.223	0.226	0.128	0.133	0.227	0.222	0.162	0.124

Figure 5.10: Stop criterion in SmartPLS

When the model's converges was reached, the PLS-SEM calculation results tables from the Default Report were used to evaluate the measurement model following criterion as shown in Figure 5.8.

Table 5.9 shows the measures' composite reliability values, Cronbach's α scores, and average variance extracted (AVE). The composite reliability values of 0.932 (P0), 0.936 (PA), 0.947 (PM), 0.933 (PP), and 0.937 (SC), and Cronbach's

α scores of 0.919 (PO, PA), 0.930 (PM), 0.910 (PP), and 0.925 (SC) demonstrate that all five latent variables (constructs) have a high level of internal consistency reliability. The AVE values of PO (0.58), PA (0.676), PM (0.782), PP (0.737), and SC (0.625) are above the required minimum level of 0.50. Therefore, the indicators of the five constructs have high levels of convergent validity.

Table 5.9: Consistency reliability and convergent validity

	Cronbach's α	**Composite Reliability**	**AVE**
PO	0.919	0.932	0.580
PA	0.919	0.936	0.676
PM	0.930	0.947	0.782
PP	0.910	0.937	0.737
SC	0.925	0.937	0.625

Table 5.11 displays the relationship between the latent variables (constructs) and their indicators (outer loadings). All outer loadings of PO, PA, PM, PP, and SC are above 0.708, except PO7 (0.699). As recommended by Hair Jr et al. (2016), 0.699 is considered close enough to 0.708 to be acceptable. Therefore, all of the indicators for the five constructs are equal to or above the minimum acceptable level for outer loadings.

Finally, the Fornell-Larcker criterion results, which are calculated by taking the square root of the constructs' AVE, are used to check the discriminant validity of the model. Table 5.10 shows that the square roots of the constructs' AVE are higher than the correlations of these constructs with other latent variables in the model in all cases. Therefore, the the constructs meet the discriminant validity assessment requirements by the cross loading.

Table 5.10: Fornell-Larcker Criterion

	PA	**PM**	**PO**	**PP**	**SC**
PA	0.822				
PM	0.506	0.884			
PO	0.680	0.455	0.762		
PP	0.516	0.661	0.435	0.859	
SC	0.577	0.553	0.578	0.591	0.791

Table 5.11: Outer toadings

	PA	**PM**	**PO**	**PP**	**SC**
PA1	0.709				
PA2	0.842				
PA3	0.878				
PA4	0.851				
PA5	0.862				
PA6	0.780				
PM1		0.853			
PM2		0.894			
PM3		0.904			
PM4		0.886			
PM5		0.883			
PO1			0.749		
PO2			0.758		
PO3			0.830		
PO4			0.820		
PO5			0.705		
PO6			0.727		
PO7			0.699		
PO8			0.731		
PO9			0.796		
PO10			0.788		
PP1				0.818	
PP2				0.831	
PP3				0.927	
PP4				0.882	
PP5				0.832	
SC1					0.838
SC2					0.788
SC3					0.731
SC4					0.764
SC5					0.798
SC6					0.799
SC7					0.841
SC8					0.825
SC9					0.722

5.5.5 Evaluation of the structural model

The evaluation of the structural model follows steps in Figure 5.9, which are based on the results of the standard model estimation, the bootstrapping routine, and the blindfolding procedure (Hair Jr et al., 2016).

The first step in the assessment of the structural model is to examine the structural model for collinearity. Collinearity, measured by variance inflation factor (VIF) values, arises when two indicators are highly correlated. The VIF value should be higher than 0.20 and lower than 5 (Hair Jr et al., 2016). Table 5.12 shows the VIF values are below 5 so collinearity among the predictor constructs is not an issue in the structural model.

Table 5.12: VIF values

	PA	**PM**	**PO**	**PP**	**SC**
PA		1.861		2.047	2.136
PM				1.387	1.932
PO	1.000			1.919	1.923
PP		1.861			1.933
SC					

Once the satisfactory result of the collinearity assessment was confirmed, key results of running the PLS-SEM algorithm were examined. The squared multiple correlations (R^2) for endogenous latent variables were initially examined to test the significance of the structural paths. According to results of the standard estimation model as shown in Figure 5.11, R^2 and corresponding path coefficients were checked to confirm the hypothesised relations between constructs in the proposed model.

The Coefficient of determination (R^2): is a measurement of the amount of variance in endogenous constructs that is explained by the predictor constructs (Hair Jr et al., 2016). According to Chin (2010), the R^2 values of PA (0.463), PP (0.483), and SC (0.507) can be considered moderate, whereas the R^2 value of PM (0.279) is rather weak.

In terms of direct effects, looking at the maturity level of SC, it seems that PP has the most influences, followed by PO. PO influences the maturity levels of PA, SC, and PM but has little bearing (0.047) on the maturity level of PP as the summary path coefficients presented in Table 5.13 suggests.

Alongside the direct effects, Hair Jr et al. (2016) recommended examining

Table 5.13: Path coefficients β

	PA	**PM**	**PO**	**PP**	**SC**
PA		0.367		0.215	0.168
PM				0.531	0.158
PO	0.680	0.205		0.047	0.269
PP					0.283
SC					

indirect effects in the structural model to gain insights into moderating or mediating effects on the latent variables. The sum of direct and indirect effects is referred to as the total effects which help explore the influences of mediating and moderating variables on the latent variables.

The indirect effects were evaluated and presented in Table 5.14 and Table 5.15. Total effects are shown in Table 5.16. The results reveal that PO has the strongest total effects on SC, followed by PA, PM, and PP. PM has the strongest total effects on PP while PO has the strongest total effects on PM. Therefore, it is advisable that, since PP has the strongest direct effects on maturity of SC, and PM has the strongest total effects on PP, the collaboration among the stakeholders needs to be addressed. Looking at the outer loadings, PP3 (preparing 10YPP) and PM3 (ensuring project implementation in an effective and timely way) have the highest outer loading in their groups. Therefore, the maturity level of the indicators (PP3 and PM3) should be improved to increase overall maturity level of SC.

The analysis of the structural model relationships showed that several path coefficients had rather low values. The statistical significance of each path was estimated by running the bootstrapping procedure to examine the proposed hypotheses. The t-value ≥ 1.65 is significant at the 0.1 level, t-value ≥ 1.96 is significant at the 0.05 level, and the t-value ≥ 2.57 is significant at the 0.01 level (Hair Jr et al., 2016). The statistical significance of each path was estimated using a PLS-SEM bootstrapping method utilising 1000 resamples to obtain t-values.

Table 5.17 displays the results of the structural model test, including the path coefficients, the t values, and their significance levels, p values, and the confidence intervals.

Table 5.14: Specific indirect effects

	Specific Indirect Effects
PO → PA → PM	0.249
PO→PA→PP	0.146
PO→PA→SC	0.144
PO→PM→SC	0.032
PO→PP→SC	0.013
PO→PM→PP	0.109
PO→PA→PM→PP	0.132
PO→PA→PM→SC	0.039
PO→PA→PP→SC	0.041
PO→PM→PP→SC	0.031
PO→PA→PM→PP→SC	0.038
PA→PM→PP	0.195
PA→PM→SC	0.058
PA→PP→SC	0.061
PA→PM→PP→SC	0.055
PM→PP→SC	0.151

Table 5.15: Total indirect effects

	PA	**PM**	**PO**	**PP**	**SC**
PA				0.195	0.174
PM					0.151
PO		0.249		0.387	0.309
PP					
SC					

Table 5.16: Total effects

	PA	**PM**	**PO**	**PP**	**SC**
PA		0.367		0.409	0.342
PM				0.531	0.308
PO	0.680	0.455		0.435	0.578
PP					0.283
SC					

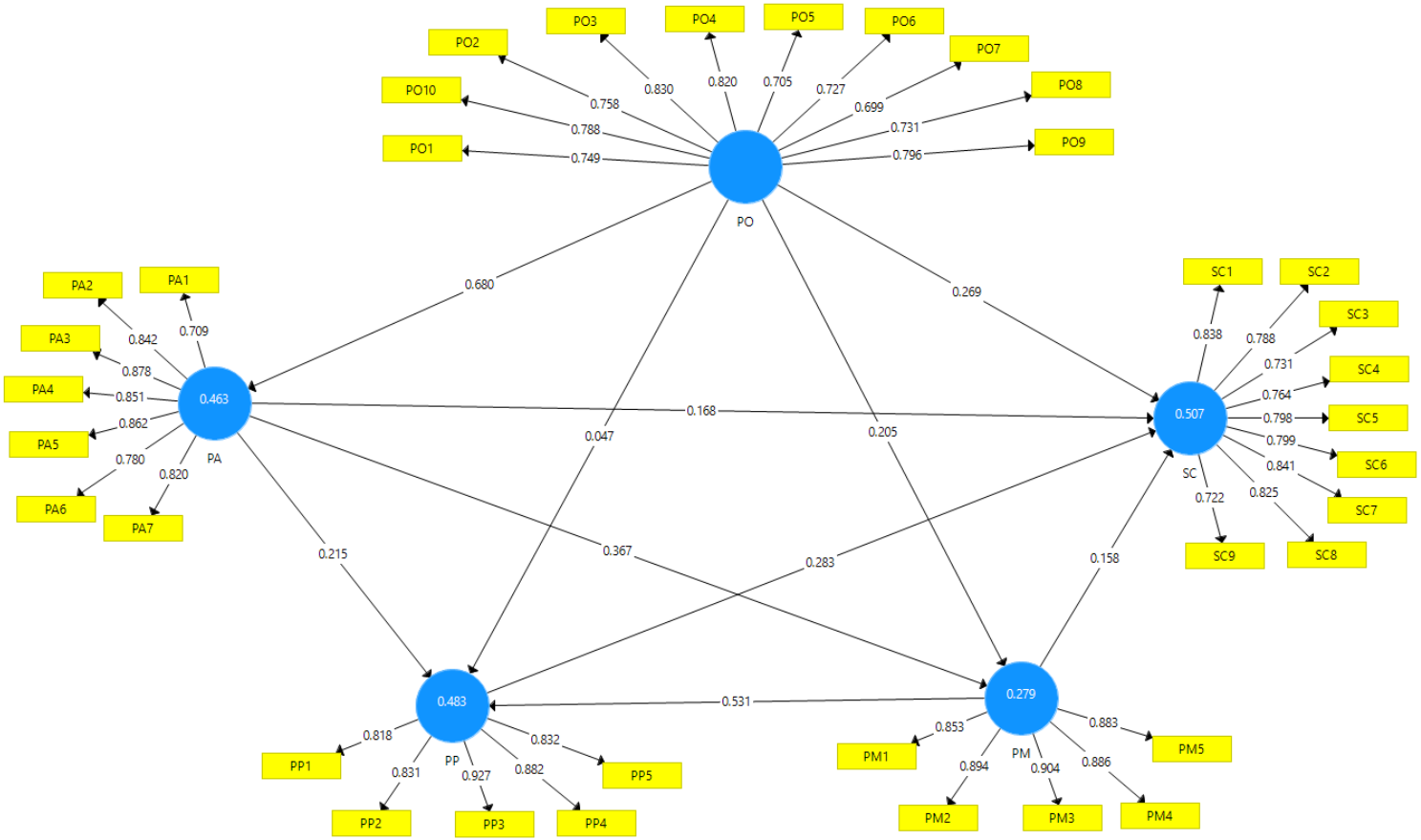


Figure 5.11: Results of the Model Estimation

Table 5.17: Significance testing results of the structural model path coefficients

	β	**t Values**	**p Values**	**Significance Levels**	**90% Confidence Intervals**
H1: PO→PA	0.68	11.583	0.000	*	[0.581, 0.773]
H2: PO→PM	0.205	2.151	0.032	**	[0.029, 0.351]
H3: PO→SC	0.269	2.793	0.005	*	[0.115, 0.437]
H4: PO→PP	0.047	0.594	0.552	NS	[-0.073, 0.182]
H5: PA→PP	0.215	2.448	0.015	**	[0.076, 0.359]
H6: PA→SC	0.168	1.735	0.083	***	[0.002, 0.326]
H7: PA→PM	0.367	3.795	0.000	*	[0.208, 0.526]
H8: PM→PP	0.531	6.148	0.000	*	[0.384, 0.662]
H9: PM→SC	0.158	1.632	0.105	NS	[0.001, 0.324]
H10: PP→SC	0.283	3.102	0.002	*	[0.134, 0.438]

Note: NS = not significant. *p $\leq$ .01; **p $\leq$ .05. ***p $\leq$ .10.

The results show that H1, H3, H7, H8, and H10 are significant at a 1% level, H2 and H5 are significant at a 5% level, and H6 is significant at a 10% level, while H4 and H9 were rejected. These results suggest that PO directly affects the maturity level of PA, PM, and SC; PA influences the maturity level of PP, PM, and SC; and both PP and PM influence the maturity level of SC. Surprisingly, PO did not directly impact PP and PM did not influence the maturity level of SC.

Table 5.18 presents the corresponding results for the total effects among the constructs. The results show that all total effects are significant at a 1% level, which means that all hypotheses are supported.

Next, an additional criteria for assessing structural models is the significance of effect size (f^2). The effect size f^2 can be assessed how much a predictor construct contributes to the R^2 value of a selected endogenous latent variable. According to Hair et al., (2014), the f^2 values of 0.02, 0.15, and 0.35 indicate if an exogenous construct has a small, medium, or large effect, respectively, on an endogenous construct.

The calculation of the f^2 value is based on the equation 5.1. The $R^2_{excluded}$ value needed for the equation is obtained by deleting a specific predecessor of that endogenous latent variable so that the path model is re-estimated. For example, the endogenous latent variable SC has an original R^2 value of 0.507 ($R^2_{included}$). If PO is deleted from the path model and the model is re-estimated, the R^2 of SC

Table 5.18: Significance testing results of the total effects

	β	**t Values**	**p Values**	**Significance Levels**	**90% Confidence Intervals**
H1: PO→PA	0.68	11.583	0.000	*	[0.581, 0.773]
H2: PO→PM	0.455	7.028	0.000	*	[0.358, 0.568]
H3: PO→SC	0.578	10.271	0.000	*	[0.489, 0.674]
H4: PO→PP	0.435	6.137	0.000	*	[0.325, 0.553]
H5: PA→PP	0.409	4.597	0.000	*	[0.268, 0.555]
H6: PA→SC	0.342	3.584	0.000	*	[0.178, 0.502]
H7: PA→PM	0.367	3.795	0.000	*	[0.208, 0.526]
H8: PM→PP	0.531	6.148	0.000	*	[0.384, 0.662]
H9: PM→SC	0.308	3.943	0.000	*	[0.181, 0.431]
H10: PP→SC	0.283	3.102	0.002	*	[0.134, 0.438]

now has a value of 0.470 ($R^2_{excluded}$). Based ib these values, the effect size f^2 of PO on SC is:

$$f^2_{PO->SC} = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}} = \frac{0.507 - 0.470}{1 - 0.507} = 0.076 \tag{5.1}$$

The other effect sizes f^2 were also calculated and the results are presented in Table 5.19. According to (Hair Jr et al., 2016), the effect size of PO on PA and PM on PP can be considered large, while other effect sizes can be considered small.

Table 5.19: Effect size (f^2)

	PA	**PM**	**PO**	**PP**	**SC**
PA		0.100		0.044	0.027
PM				0.393	0.026
PO	0.861	0.031		0.002	0.076
PP					0.084
SC					

The final step in the assessment of the structural model is to assess the predictive relevance of the path model (Q^2) and the effect size of Q^2 (q^2) by applying the blindfolding procedure. The q^2 effect size of a selected construct is calculated by using a similar equation as previously applied to f^2, but in this case, R^2 is replaced by Q^2. According to Hair Jr et al. (2016), the path model has predictive

relevance for a selected endogenous construct if the Q^2 value is above zero; q^2 values of 0.02, 0.15, and 0.35 respectively indicate that an exogenous construct has a small, medium, or large predictive relevance. Table 5.20 provides the Q^2 values (along with the R^2 values) of all endogenous constructs. The results show that all Q^2 values are above zero, thus providing support for the model's predictive relevance regarding the latent endogenous variables.

Table 5.20: predictive relevance value (Q^2)

	R^2	Q^2
PA	0.463	0.309
PM	0.279	0.213
PO		
PP	0.483	0.344
SC	0.507	0.304

The calculation of q^2 value follows the equation 5.2, where the $Q^2_{excluded}$ value is obtained after deleting PO from the path model. The model the re-estimates the Q value. In the current data set, the Q^2 of SC has a value of 0.282 ($Q^2_{excluded}$). The effect size q^2 of PO on SC is:

$$q^2_{PO->SC} = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}} = \frac{0.304 - 0.282}{1 - 0.304} = 0.031 \tag{5.2}$$

The other effect sizes q^2 are presented in Table 5.21. According to effect size's interpreting proposed by (Hair Jr et al., 2016), the effect size of PO on PA can be considered large, and PM on PP can be considered medium, while other effect sizes can be considered small.

Table 5.21: Effect size (q^2)

	PA	**PM**	**PO**	**PP**	**SC**
PA		0.070		0.021	0.010
PM				0.224	0.010
PO	0.444	0.002		0.000	0.031
PP					0.037
SC					

The results reveal that PO has the strongest total effects on PA, PM and SC, while PM has the strongest total effects on PP. In addition, PP has the strongest direct effects on SC and PA has the strongest total effects on SC. The results

highlight that the different stakeholders influence each other, which provides further evidence for the suggestion that the relationships between stakeholders are crucial for the success of BMM. The interrelationships should be considered when proposing the most needed areas for improvement.

5.5.6 Discussion for key areas for improvement

According to maturity level results, all indicators' mean scores are less than level 4. This finding indicates that elements in PMMS have not been performing effectively and the maturity levels should be improved. It is necessary that the relationship between the indicators and constructs and among the latent variables should be investigated.

When considering the maturity level scores alongside relationships among the indicators and the constructs, priority levels for improvement can be recommended. Indicators which have mean scores below Level 3 of PO are suggested to be high priority for improvement. Moderate priority for improvement is suggested for indicators with mean scores below level 3 of PA, PP, PM, and SC and indicators with mean score between level 3 and level 4 of PO. Low priority for improvement is recommended for indicators with mean scores between level 3 and level 4. Therefore, the most needed areas for improvement include:

- Providing training programs for people involved in PMMS (PO5)
- Establishing a performance evaluation framework for PMMS (PO6)
- Establishing a reporting system for collecting required information (PO8)
- Reviewing the PMMS system against the long-term strategy (PO9)
- Enhancing improvement actions for better delivery of PMMS (PO10)

The moderate priority for improvement focuses on activities relating to policy and strategy (PO1, PO2), communication (PO3), engagement (PO4, PA3, PA7), sharing lessons (PA6, SC9), and preparing funding for PMMS (PO7, PP4). The priorities for improvement are sorted in Table 5.22.

The research hypotheses propose that stakeholders directly influence each other. PO was assumed to directly affect PA, PM, and SC, so improvements of indicators for PO would enable improvements of indicators for PA, PM, and SC. In all cases, it is important that top-level managers believe that the improvement

Table 5.22: High and moderate priority areas for improvement

Code	Element	Priority
PO5	Providing training programs for people involved in PMMS	High
PO9	Reviewing the current system against the long-term strategy	High
PO10	Enhancing improvement actions for better delivery of PMMS	High
PO6	Establishing a performance evaluation framework for PMMS	High
PO8	Establishing a reporting system for collecting required information	High
PA6	Sharing knowledge and lessons to help schools resolve property issues	Moderate
PA7	Helping schools improve their property maintenance outcomes	Moderate
SC9	Collecting and sharing lessons for improvement of the PMMS	Moderate
PP4	Estimate the required funds for 10YPP plan	Moderate
PA3	Supporting schools to complete their property plans	Moderate
PO3	Providing communication protocols for people involved in the PMMS	Moderate
PO7	Calculating and paying funding for PMMS	Moderate
PO4	Defining roles and responsibilities of all people involved in PMMS	Moderate
PO1	Developing long-term strategies for PMMS	Moderate
PO2	Providing policies for delivery of PMMS	Moderate

actions are necessary and act accordingly (Erdogan et al., 2008). Dulaimi et al. (2007) agreed with the view as the authors state that collaboration had been championed at the highest levels of the organisation. In PMMS, it is important that the MoE recognises the need for improvement, then policies, processes, and procedures support the collaboration can be issued accordingly. It is understandable that all PO's responsibilities are found at high priority (PO5, PO9, PO10,PO6, PO8) and moderate priority (PO1, PO2, PO3, PO4, PO7) areas for improvement.

Regarding the highest priority improvement areas, this study clearly demonstrates the need to evaluate the current processes, engage in lesson analysis,

and promote improvements for PMMS (PO6, PO8, PO9, PO10). These findings are consistent with research by Rahmat and Ali (2010) and Newig et al. (2008), who highlighted that monitoring and evaluating the performance ensures that processes have been carried out as planned and that the outcomes meet the stakeholders' expectations. The information collected in the monitoring and evaluation processes serve to generate lessons to improve the effectiveness of the management.

The path coefficient values show that PP has the strongest impacts on SC, while PM has the strongest effects on PP, and PA has the strongest influence on PM. This finding is supported by Kalay (2001) who pointed out that combining abilities of actors helps complete given tasks more quickly and efficiently. Considering that collaboration is an activity where a complex task is achieved by combining the abilities of different people (Lang et al., 2002), it follows that the success of a collaboration heavily relies on the competence of the individuals. Therefore, abilities of the key stakeholders (PO4) should be clearly defined to maximise the effectiveness of the collaboration. Quality of workmanship, including training, awareness, and competence of employees have a significant influence on the effectiveness and efficiency in the built environment (Adeyeye et al., 2013; Ling, 2004). In addition, appropriate training programmes (PO5) and performance evaluation framework (PO6) are critical to ensure necessary competencies for PMMS. Three most needed improvement competences were identified for PMMS including PA6, PA7, SC9 and PP4.

The findings also emphasise the importance of engagement and communication between the people involved in PMMS (PO3, PA7), as these indicators are suggested for moderate priority areas for improvement. Hackman (2008) acknowledged that communication between top management at strategic levels and maintenance personnel at operational levels are powerful for influencing the performance of property and maintenance activities. Communication usually refers to the patterns of exchanging information and knowledge with the aim to develop a common ground and goals (Turkulainen et al., 2015). Thus, effective communication helps reduce misunderstanding or misinterpretation among different parties (Al-Reshaid and Kartam, 1999), and ensure maintenance strategies are carried out as planned (Salah, 2016). However, communication within project-based environments such as PMMS presents significant challenges as a result of both the temporary and inter-disciplinary nature of project teams (Dainty et al., 2007).

In the context of PMMS, because the participants are based in different locations and often do not interacted in person, effective communication methods are crucial for the success of the collaboration (PO3). It is critical to improve stakeholder communication to ensure the effective engagement of different stakeholders in different phases of projects Turkulainen et al. (2015).

The results highlight the requirement to establish an effective information management system and a feedback loop that help the MoE understand what schools need the most and allow schools to respond to MoE's requirements (PO8, PA6, SC9). ISO 55000 (2014) and (Kelly et al., 2005) suggested that information is essential at all stages of asset management. Accurate and adequate information about the property condition and its performance enable managers to make informed and practical decisions in the planning stage (PO7, PP4). In addition, information management is needed to improve transparency and reduce conflicts throughout the duration of a collaboration (Shelbourn et al., 2007). Because key stakeholders in PMMS are based in different offices, and they often do not interact in person, so a system to relay relevant information is critical for the stakeholders to collaborate effectively.

There is a need to provide clearer guidelines for gathering reports, providing feedback, and sharing lessons learnt during and after each project in PMMS. The standard reports can confirm what type of information should be shared and outline the criteria used for evaluations. Such an information management system would also help SC review their maintenance conditions and budget spent with other neighbor schools to help them find cost-effective solutions. At school level, it is important that schools continuously record and update their property and maintenance information and report the information to the MoE (SC9). Relating information is important to perform maintenance tasks properly (Gómez-Chaparro et al., 2020) and make decisions for future renewal alternatives such as renovation or refurbishment. Therefore, both the MoE and schools should pay attention to the information management of all property and maintenance work and provide the information for other stakeholders if required.

5.6 Summary

The quantitative data analysis shows the maturity levels of all variables considered the research model. The maturity scores revealed that there is no indicator

which has a maturity score greater than Level 4. There are ten indicators which have maturity scores between Level 3 and Level 4. The results reveal that the measurement model and structural model were evaluated and satisfied. The research hypotheses were supported by statistical analysis. Therefore, the most needed areas for improvement of PMMS are identified including staff training, performance evaluation, lesson analysis and sharing, and communication. Based on the discussion of the most needed areas for improvement, a framework for PMMS will be developed and validated in the next Chapter.

Chapter 6

Framework Development and Validation

6.1 Introduction

Based on findings from the literature review, preliminary study, interviews, and questionnaire survey, a new framework for PMMS was developed. The framework aims to enable all PMMS stakeholders to engage in effective collaboration for improvement of PMMS. The framework achieves this aim by integrating all input, output, and control elements of each activity. Using the resource available effectively, sharing responsibility across processes and achieving long-term goals are key contributions of this framework.

This chapter starts with an introduction to the proposed framework, which is based on the findings from the literature review (Chapter 2), preliminary and interviews' findings (Chapter 4) and key areas for improvement (Chapter 5). This section describes the design and development methodology and components in the proposed framework. This section also provides guideline information for users. The second section of this chapter describes the validation process. Advantages and limits of the framework are discussed in order to improve PMMS. The section summarises the key improvement of proposed framework and actions that can facilitate the implementation of the proposed framework in practice.

6.2 Framework design

The methodology used for the development of the new framework proposed in this research is based on the Plan, Do, Check, Act cycle (PDCA). The PDCA cycle concept was developed by William Deming (1950s) as a method for continual improvement of processes or systems and changing management practices. It helps improve the performance of processes systematically. The four steps of the cycle can be summarised as follows:

- Plan: In this phase, objectives and processes required to deliver the expected results are established, including detailed descriptions and specifications. Team members are selected and a schedule is established for the implementation of the plan. Necessary resources are prepared and allocated.
- Do: Organisations implement all tasks of the plan according to the schedule. Implementation data and results are gathered and reported to the stakeholders.
- Check: Data and results gathered are evaluated and compared to the expected outcomes to identify similarities and differences. All changes, difficulties, successes, and challenges that happened in the implementation phase are recorded. Then the root causes are recorded and analysed.
- Act: Based on the results in the preceding step (Check), preventative and corrective actions are taken for improvement. The PDCA cycle is repeated until all goals and objectives are achieved and stakeholders are satisfied with the project results.

Regularly improved, the PDCA cycle has been applied across industries and organisation types (Gidey et al., 2014). The PDCA cycle has also been used for the development of the ISO 55000 framework (Patiño-Rodriguez and Carazas, 2019), which helps organisation achieve standards of ISO 55000. Márquez, López, Rosique and Márquez (2018) argued that the framework offers opportunities for top management to re-examine and refine their management model. It also helps to improve relationships between key stakeholders and enhance stakeholders trust. Van Der Voordt et al. (2016) adopted the PDCD cycle to develop a new value-adding management model for cooperate real estate management. The key actions in their new model was to define interventions that may add more value to the organisational objectives. Because of the benefits of the PDCA cycle,

it was adopted to develop the new framework, which includes one more stage (Establish-Plan-Implement-Evaluate-Improve).

The Integrated Function Modelling Method (IDEF0) was adopted to develop the lower level of the framework. The principal strength of the IDEF0 method is that it is effective in describing activities and detailing system activities (Integrated DEFinition Methods (IDEF), 2019). IDEF0 enables the description of processes using greater detail of each activity, meaning that users can more easily understand the progress and see which areas should be improved. As show in Figure 6.1, the IDEF0 technique uses simple modelling language of boxes and arrows, which makes it easy for users to understand and interpret the information. The hierarchy details of the activities also help increase the effectiveness of communication between all people involved in the process. The method was employed to both develop the framework for building maintenance management for schools (Akasah et al., 2010), and enhance collaboration in construction projects (Erdogan et al., 2008). Therefore, IDEF0 has been recognised as the most appropriate method for modelling processes such as those involved in PMMS.

Figure 6.1 represents a model IDEF0 diagrams which is read from left to right, top to bottom to help the users recognise which activity belongs to which section. **Inputs** are data or objects that are transformed by the activity into an output, while **Outputs** are data or objects that are produced by the activity. **Controls** define the conditions required to produce the correct output and **Mechanisms** are the means used to perform the activity. IDEF0 diagrams are designed to help illustrated all relevant information that users may need such as what type of input an activity requires, what type of result can be expected from the activity, who performs the activity, and what is needed for the activity to be performed properly.

In the context of PMMS, inputs and outputs are usually come in form of information, data, and documents and these forms and contents differ from activity to activity. In each section, outputs of previous activities can be inputs of subsequent activities. Primary control elements are marked by yellow coloured arrows in the figure. These mechanisms refer to the people who perform activities: SC, PA, PP and PM. The person who is responsible for performing the activity is coded using red coloured text, collaborators of the activity are in blue.

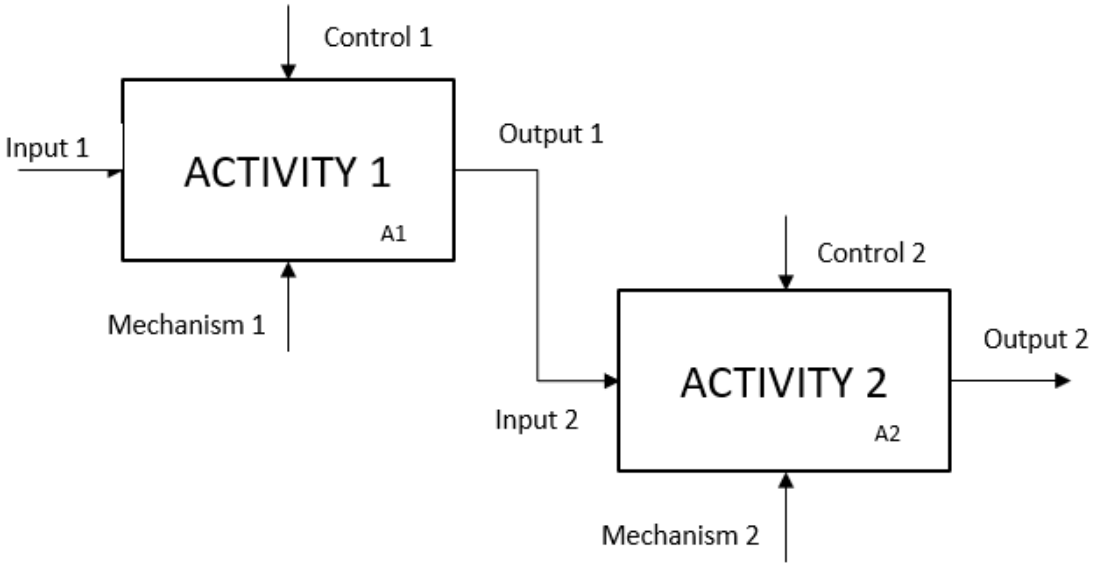


Figure 6.1: Basic IDEF0 model. Developed from (Integrated DEFinition Methods (IDEF), 2019)

6.3 Introduction of PIE

6.3.1 Sub-processes, and activities in PIE

Based on the most needed areas for improvement, the Plan-Do-Check-Act cycle was adopted to develop five distinct sub-processes in PMMS: **E**stablish-**P**lan-**I**mplement-**E**valuate-**I**mprove (E-PIE-E is shortened to PIE). The activities in each sub-process were identified from the findings in the literature review (Chapter 2), preliminary study and interviews' findings chapter (Chapter 4), and quantitative data analysis (Chapter 5). The main aim of developing processes and activities in PIE is to help SC, PA, PP and PM clearly understand activities in PMMS, input, output, control elements of each activity. It also helps the actors recognise their responsibilities, and how to collaborate with others at each stage.

The activities were coded and and sorted in each stage as shown in Figure 6.2. The purpose of **Establish** is to solve the challenges in the existing process of PMMS. As presented in Chapter 4, the stakeholders experienced lack of a shared vision in PMMS, due to the multi-layered relationships and external consultants only involve in specific tasks. Activities in Establish, therefore, aim to promote training, understanding, and engagement of the stakeholders, which help create a shared vision between the stakeholders in PMMS. The Plan and Implement sub-processes in the PIE framework are mainly based on current activities but

in more detailed. The first activity in Plan and Implement sub-processes was added to promote a shared vision among people involved in specific tasks. The Evaluate and Improve stages have similar purposes with the Check and Act in the PDCA cycle. Therefore, the needed improvement areas (feedback collection, lessons learned, performance evaluation, and information sharing) are addressed in the new framework. Figure 6.3 illustrates the activities and their relationships in the whole PMMS process.

Stages	Activity name	ID
A1 - Establish	Establish PMMS policies	A11
	Understand PMMS policies	A12
	Understand school's needs and wants	A13
	Attend training	A14
	Understand roles, responsibilities in PMMS	A15
	Establish a shared vision	A16
A2 - Plan	Engage people involved	A21
	Conduct condition assessment	A22
	Prioritise property projects, maintenance tasks and estimate budget	A23
	Agree and submit property plan	A24
	Approve plan and allocate budget	A25
A3- Implement property projects	Engage people involved	A31
	Initiate projects	A32
	Implement and monitor projects	A33
	Close projects	A34
	Signoff and hand over projects	A35
A3* - Implement maintenance work	Develop maintenance cost plan	A3'1
	Finalise maintenance tasks	A3'2
	Schedule maintenance tasks	A3'3
	Select contractors and carry out works	A3'4
	Close maintenance works	A3'5
A4 - Evaluate	Collect feedback/reflections	A41
	Evaluate performance	A42
	Analyse lessons	A43
A5 - Improve	Address corrective/improvement actions	A51
	Take corrective/improvement actions	A52
	Capture and share knowledge	A53

Figure 6.2: PMMS activity names and codes

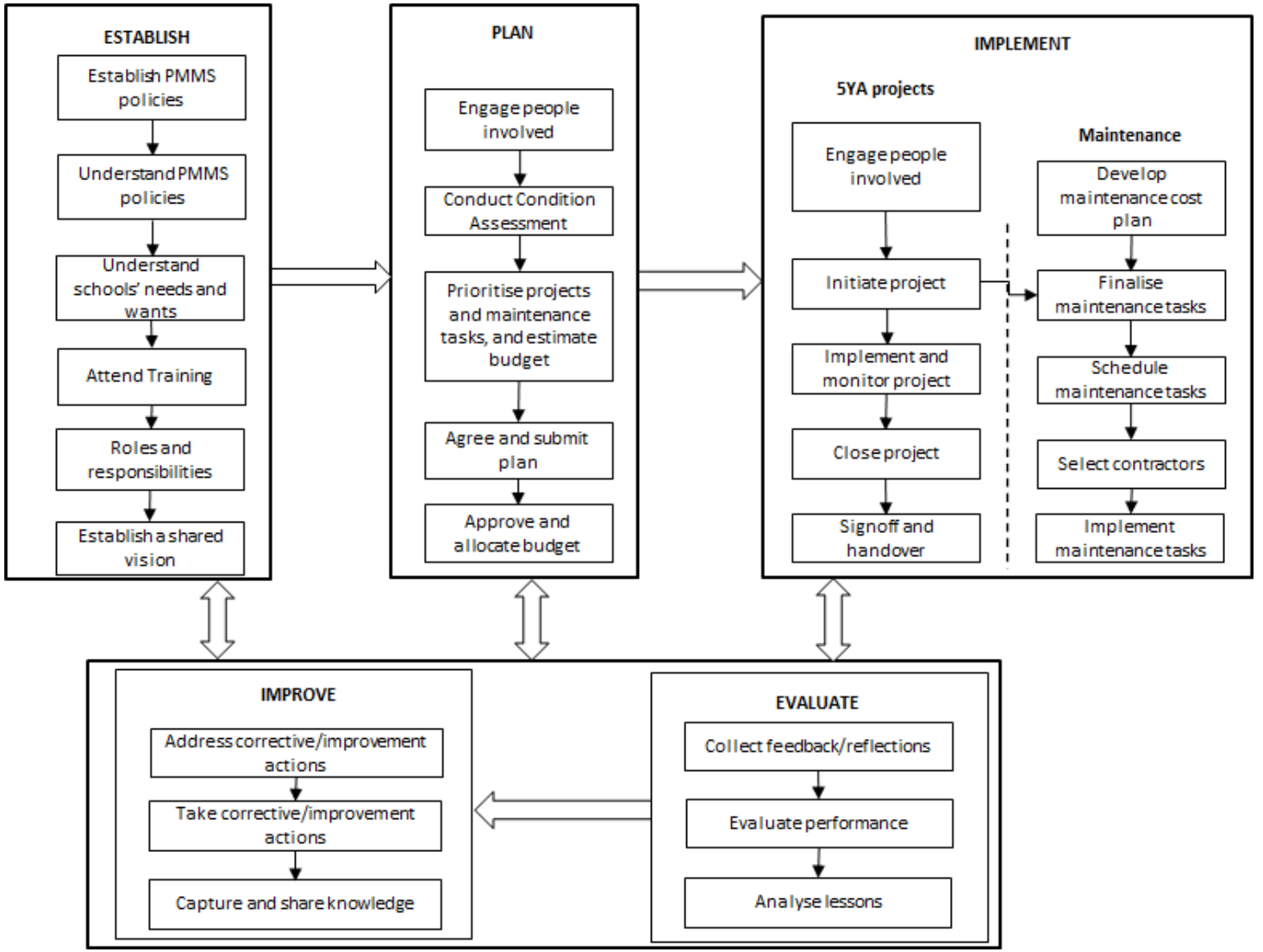


Figure 6.3: PIE framework

Diagrams illustrating how the roles and responsibilities related to the activities associated with each PMMS process is presented in next sections. These diagrams can help those involved visualise and understand their roles, the roles of those they are working with, stages of their job, activities that need to be done before and after each step, as well as the input, output, and control of each activity.

Practitioners follow this framework by starting in the top left corner and then working down from the top of each section. In the **Establish** section, the MoE's leadership role is described on the left, and the roles of SC, PA, PP, and PM are listed on the right. In the **Implement** section, tasks related to 5YA projects are listed on the left, while all the activities mentioned on the right are managed by the schools alone. Tasks identified in the **Evaluate** and **Improve** sections are not time restricted, and can be undertaken at any stage of PMMS. However, it may be advisable to engage with Evaluate and Improve activities either after each stage or even more frequently to ensure all information needed for strategic decision making is up-to-date.

6.3.2 Establish

Details of the activities and their connections are presented in Figure 6.4. The diagrams is read from left to right, and top to bottom. The Establish starts with establishment of MoE's policies (A11) for PMMS includes:

- financial resources and allocation
- qualifications, roles and responsibilities of people involved in PMMS
- accountability and channels of communication
- standard working procedures and monitoring
- performance evaluation and feedback systems
- information management

PO establish and develop the policies (A11), while all people involved have to understand all the policies to do their jobs (A12). Input elements of A11 are documents and information provided by the MoE such as school property strategy and resources. The output of A12 is understanding of the policies and requirements for PMMS, which is one of the inputs of A16. Alongside understanding official MoE's policies, people involved in PMMS also need to understand the specific school context and the school's development plans (A13) in order to produce

develop appropriate plans and implement the approved projects effectively. The output of A13 is defining schools' needs and wants for PMMS, which is another input needed for A16. At A13, schools are able to determine if they follow current model or they want to move to a centrally managed model (discussed later).

Along with the current training courses as mentioned in Chapter 4 (10YPP and condition assessment course), those involved in the provision of PMMS need to attend on-going training programmes to help them understand roles, responsibilities, accountabilities and communication in PMMS. Training programmes also provide an up-to-date required competencies for PMMS. The output of A14 is competent staff for PMMS, which is also one of the inputs of A16. Training documents, knowledge and experience of performing the tasks in PMMS should be stored online, which enable all stakeholders to access at anytime. The final activity in Establish is A15-Establish a shared vision and common goals for PMMS. All outputs of previous activities are inputs of A16. And the output of A16 is an understanding of a shared vision and common goals for PMMS by the stakeholders. A summary of input, output, control and mechanism of all activities in Establish are presented in Table 6.1. The outputs ensure that the people involved in the process share a vision, earn the trust, and be ready to perform their jobs.

Table 6.1: Activities in Establish

Code	**Input**	**Output**	**Control**	**Mechanism**
A11	Long-term strategy for PMMS, resources	MoE's policies for PMMS	MoE governance and leadership	PO
A12	MoE's policies	Understanding PMMS goals and objectives	Communication, training	All people involved
A13	School's charter, School board's interests	School's needs and wants for PMMS	Communication, training	All people involved
A14	Training programmes	Competent people	Training methods	All people involve
A15	Defined roles and responsibilities	Understanding roles and responsibilities	Communication, training	All people involved
A16	Outputs of A11, A12, A13, A14	Agree on shared vision and common goals	Communication, contracts	All people involved

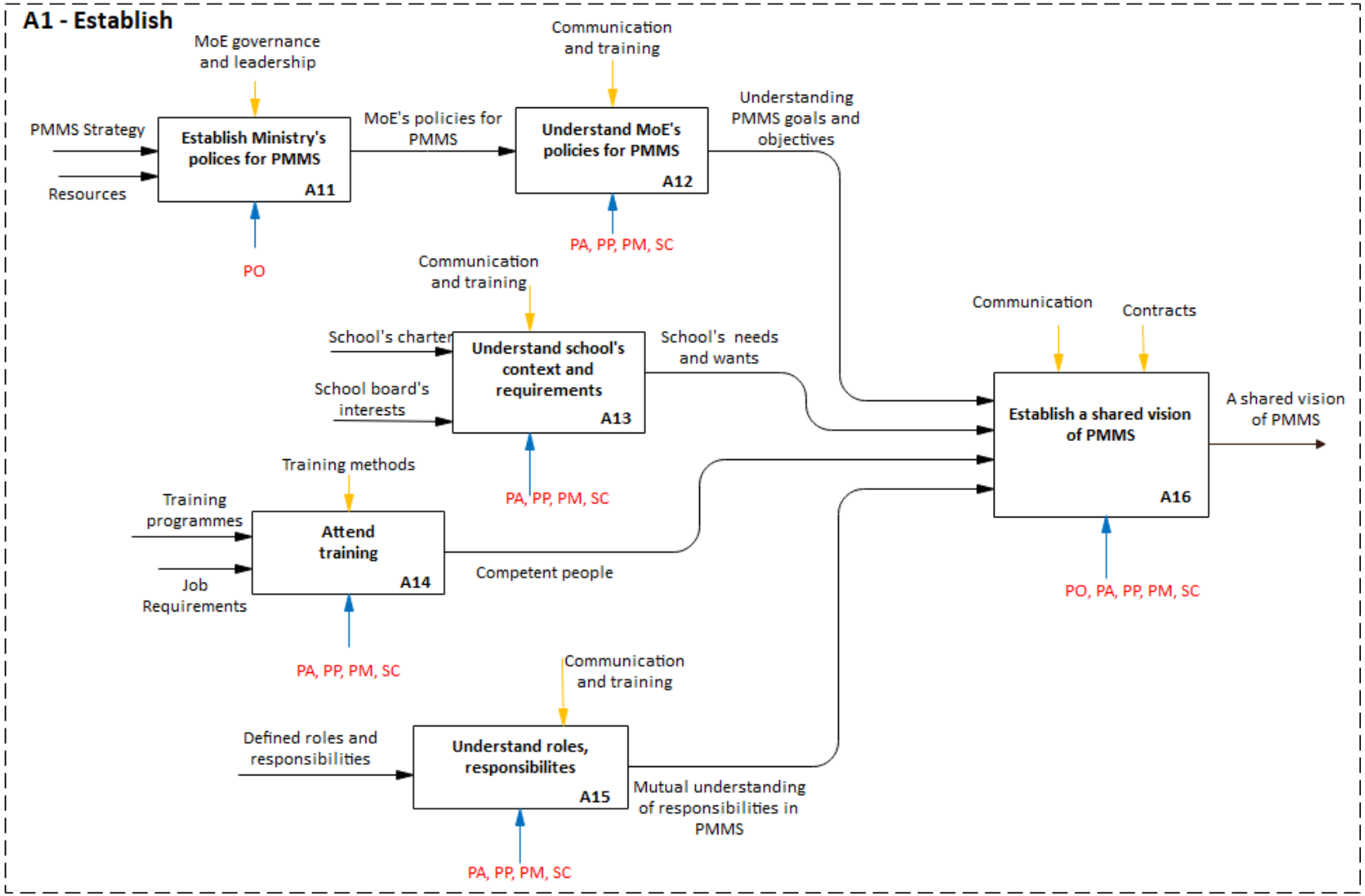


Figure 6.4: Establish stage in PMMS

6.3.3 Plan

The aim of the Plan process is to develop a long-term property plan for schools. This process is captured activities from 10YPP process as described in Figure 2.12. There are six activities in the Plan, from A21 to A26, as shown in Figure 6.5. PA, PP and SC are the people who perform the activities. The Plan process starts with Engagement of people who involved in the Plan process (A21). Outputs of A11 and A12 in Establish are inputs of A21. The outputs of A21 are common goals and objectives of PMMS in next 10 years in conjunction with the long-term development plan of the school. The Ministry's policies (P) including the process, procedures and resources, competencies of people involved (C), technology (T) are the conditions required to produce the correct outputs for this process.

In Conduct condition assessment activity (A22), alongside output of A21, history data of previous property projects and specialist reports such as electrical and pumping reports is another input. PP coordinate with SC to review the history of property projects by examining documented information and then conducting a condition assessment to identify all property matters that will need to be addressed in the next 10 years. Therefore, information on previous projects recorded by project managers is critical for the condition assessment. Based on the property matters investigated, PP, together with SC and PA, prioritise the projects for the next ten years (A23). The budget required for the plan is estimated by PP. PP's estimation is informed and advised by SC and PA about the school's context as well as by available resources. It is claimed by school managers during the interviews that the estimated budget for 10YPP is not realistic resulting in "half-solutions" problems as mentioned in Chapter 4. Therefore, at this stage, PP should consider the specific school's context including its location.

PP need to ensure that preparing the property plan complies with the guidelines and MoE requirements and other statutory obligations. Once SC are satisfied with the plan, PP can submit the plan to MoE for approval (A24). MoE checks and approves the plan if it meets the policy and funding criteria. Once MoE has approved the plan, agreements are signed, and the budget is released for the school to implement the approved projects (A25). A summary of input, output, control and mechanism of each activity is presented in Table 6.2.

The key improvement point of this Plan process in comparison with the current model is the collection of feedback, evaluate performance and capture knowledge after each activity that ensure accountability for decisions made. Condition

Table 6.2: Activities in Plan

Code	**Input**	**Output**	**Control**	**Mecha-nism**
A21	Defined responsibilities, a shared vision	Common goals and objectives	P-C-T	PA, PP, SC
A22	MoE's requirements, school's needs and wants, common goals and objectives, history data, specialist reports	All property matters in next 10 years	P-C-T	PA, PP, SC
A23	All property matters, risks, costs, and statutory obligations, school context	Prioritised property projects and maintenance tasks, estimated budget	P-C-T	PA, PP, SC
A24	Required projects, MoE requirements	10YPP plan	P-C-T	PA, PP, SC
A25	10YPP plan	Plan approval and budget release	P-C-T	PO

data of school buildings and infrastructure should be systematically captured and stored at both MoE and school levels. Analysis of the data can provide an opportunity to MoE to review the policies for funding. The collected data also can provide a database of maintenance cost for occupancy of schools at regional basis. School buildings, as mentioned in Chapter 2, range from new to 50 year old buildings. Some very old buildings with critical issues, may need to spend more money on their maintenance than the is justified by their size and students, while the newest schools which may require less maintenance expenditure in a few years. Schools located near a coast or rural schools should receive more budget for their maintenance due to deteriorate far more rapidly and lack of service providers in their areas. These practical problems can be solved through the allocation of the budget on a regional basis. Therefore, planning the property projects must be developed with regards to the actual needs of schools to ensure that maximum benefits are obtained from the money spent on PMMS.

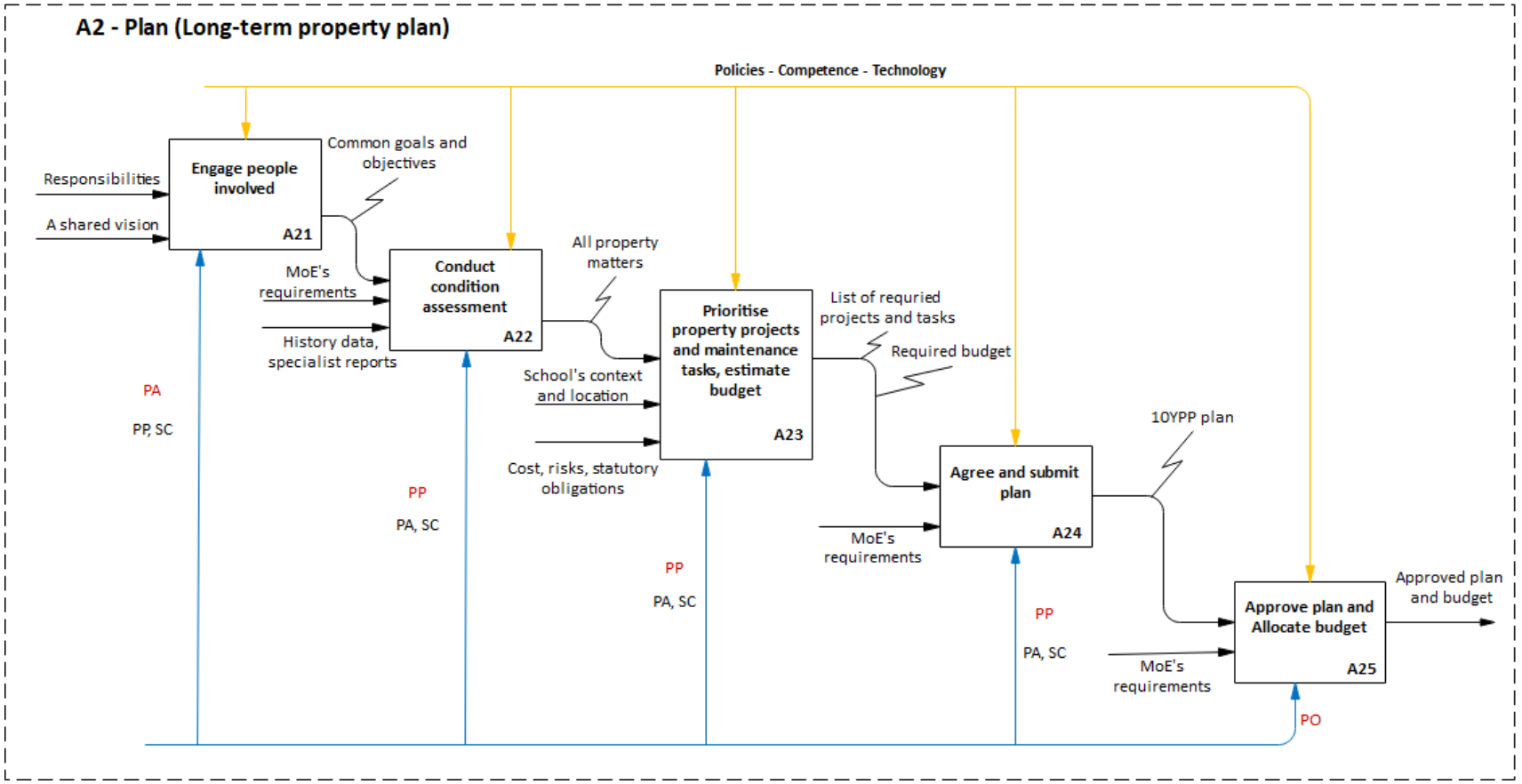


Figure 6.5: Plan stage in PMMS

6.3.4 Implement

6.3.4.1 Implement 5YA project

Due to the work category in PMMS, as presented in Figure 2.11, there are two types of implementation in this process: property projects (A3) and maintenance work (A3*), as shown in Figure 6.6. The main difference of the two types of implementation is the management of property projects involving an external PM involve a number of steps, while schools can manage the maintenance work themselves. The Ministry's policies (P) including the process, procedures and resources, competencies of people involved (C), and technology (T) are the conditions required to produce the correct outputs for this process. Similar to A2, A3 starts with the engagement of people involved in the process (A31) to set up common goals and objectives for implementing projects. The input of A31 is the project brief including the objectives, time frame and budget.

Table 6.3: Activities in Implement

Code	**Input**	**Output**	**Control**	**Mechanism**
A31	Project brief	Agree standards and procedures, a project file	P-C-T-I	PA, PM, SC
A32	Agree standards and procedures, MoE's guidance and templates	project scheduling, procurement plan, selected contractors, contracts	P-C-T	PM, SC
A33	A32's outputs, available resource	project completion	P-C-T	PM
A34	MoE's requirements, local council requirements, project completion	project documentation, project completion	P-C-T	PM, SC
A35	project documentation, and reports	project handover	P-C-T	PA, PM, SC

In A32, Initiate project, PM coordinate with SC to discuss progress of the project, procurement plan, tender documents, contracts and payments. Health

and safety hazards also need to identified at this stage to keep people at schools safe during the implementation. A project file should be create at this stage to store all relevant information about the project and be added and stored by PM. Then, the procurement is processed to select contractors and implement the work package (A33). PM is responsible for managing project delivery, problem solving, dispute management and information sharing. All PM, SC, and PA have a vital role in monitoring the projects to keep track of the projects' progress, review financial update, and react to issues when they occur (A34). When the projects are completed, it is important that PM collect all the guarantee and maintenance care documents from the contractors and building suppliers for the school (A35). Schools can include maintenance requirements for building products as inputs in their maintenance programmes. Before signing off the projects, PM need to return the project file containing all final paper work, such as drawings, contracts, contractors' reports, to the schools , and updates in the MoE database as required (A35). PM, PA and SC need to agree at the final stage that the project completed as its defined objectives and complete financial statement for each project.

Although the PM's indicators are between level 3 and level 4, as the results in Chapter 5, pointing out that PM have fulfilled their role in PMMS, school managers claimed during the interviews that there was a lack of evaluation and information management in PMMS. Therefore, in this new framework, post-implementation evaluation and information exchange are highlighted at Evaluate and Improve process. Inputs and outputs of the activities are summarised in Table 6.3, and displayed in Figure 6.6.

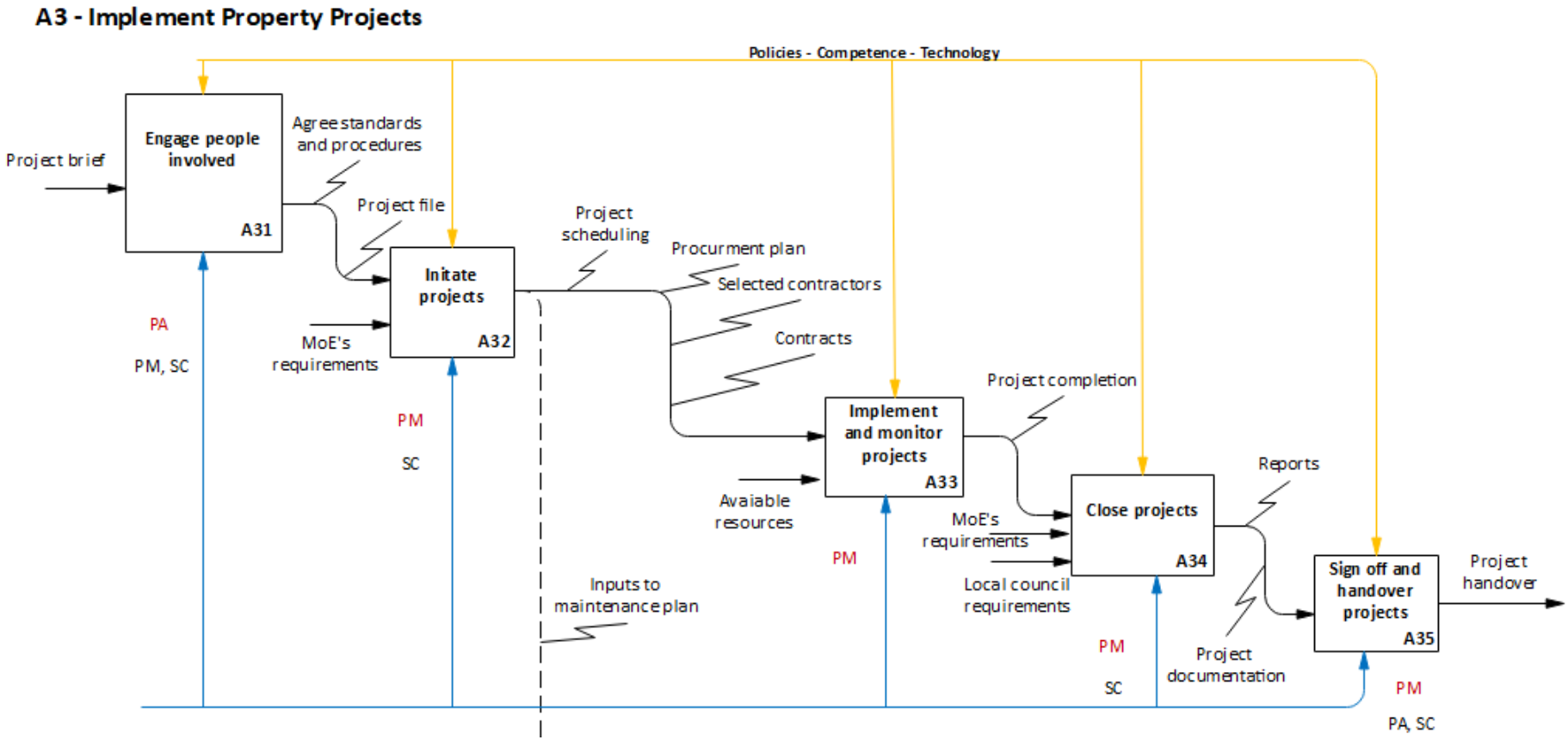


Figure 6.6: Implement 5YA in PMMS

6.3.4.2 Implement maintenance work

At A13, schools are able to determine if they follow the existing model as they can maintain their property, or if they find maintenance management is burden for their school boards, they can move to a centrally managed model. This section, firstly, describes the existing model and a proposed centrally managed model (see figure 7.1 is followed.

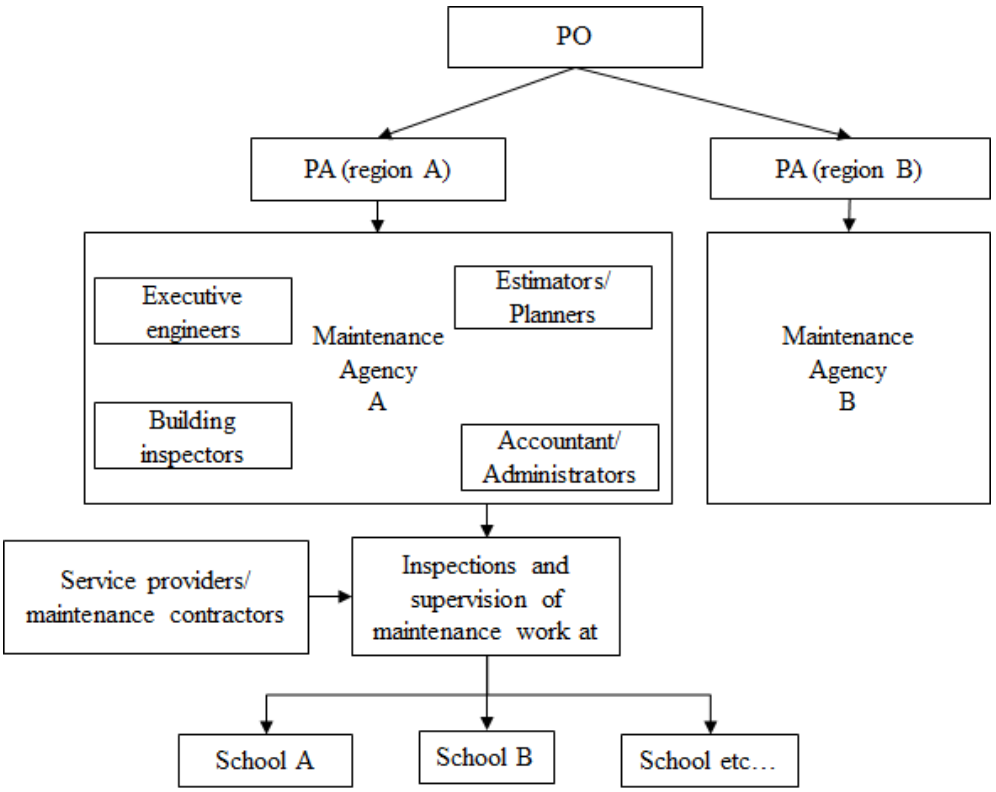


Figure 6.7: Centrally Managed Model

Despite the management approach adopted, except urgent repairs listed in MoE's guide, it is critical to develop the maintenance cost plan (A3'1), finalise maintenance tasks (A3'2), schedule maintenance tasks (A3'3), select contractors (A3'4), and close maintenance work (A3'5). The inputs and outputs of those activities between the two approaches are the same, only actors of each activity would be SC or the agency. In the existing model, SC maintain their property using the PMG, while in the centrally managed model, SC only involve in reporting maintenance issues and providing required information. The maintenance work should align with the previously determined order of property project (A3) to maximise the effectiveness of a sequence of work. Maintenance contractors

are then selected to perform certain tasks, and SC or the agency record and update the condition of their buildings and property to the database after the work is completed. Details of the inputs, control, mechanism, and outputs of each activity are summarised in Table 6.4 and displayed in Figure 6.8.

Table 6.4: Activities in Maintenance

Code	**Input**	**Output**	**Control**	**Mechanism**
A3'1	10YPP, maintenance budget, history maintenance	maintenance cost plan	P-C-T	SC or Agency
A3'2	5YA projects, risks, statutory obligations, planned maintenance	list of maintenance tasks	P-C-T	SC or Agency
A3'3	List of maintenance tasks, school operational plan	maintenance programmes	P-C-T	SC or Agency
A3'4	Maintenance programmes, available resources	maintenance completion, maintenance documentation	P-C-T	SC or Agency
A3'5	Maintenance completion, maintenance documentation	maintenance outcomes	P-C-T	SC or Agency

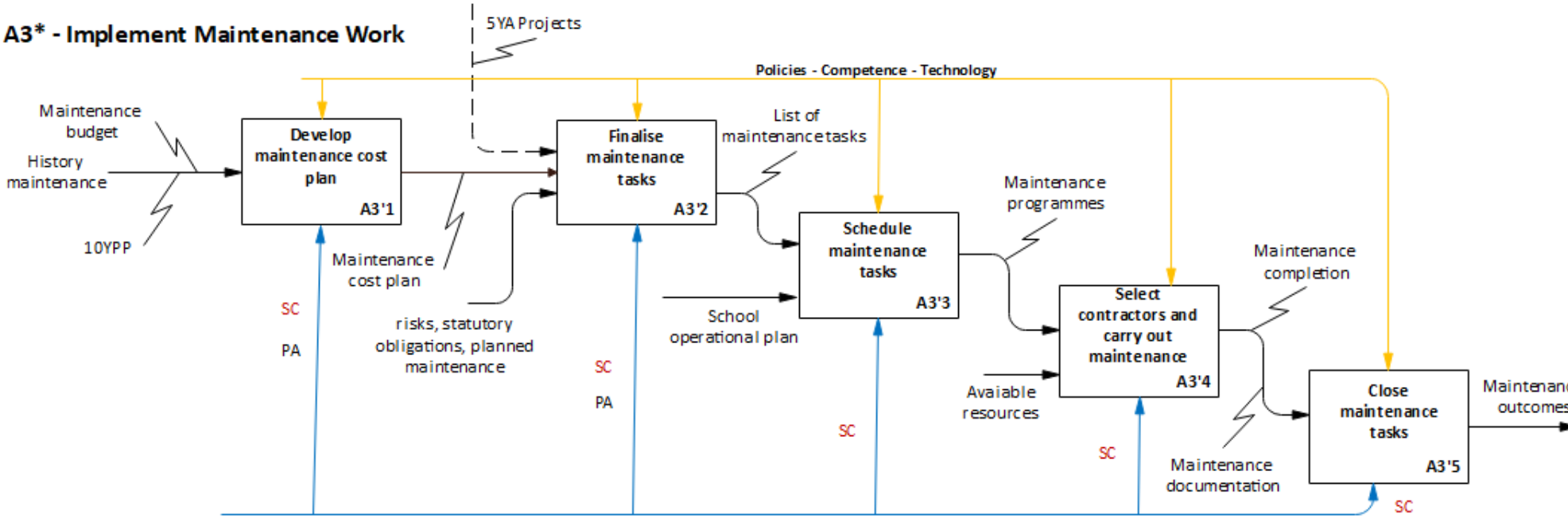


Figure 6.8: Carry out maintenance work in PMMS

6.3.5 Evaluate and Improve

The A4-Evaluate and A5-Improve stages can be completed at any time in PMMS following the processes identified in Figure 6.9. Reports and documents collected after each activity completion are inputs of A41. PA coordinate with SC, PP, and PM to collect all feedback for completed projects/activities. Based on evaluation criteria agreed by all parties, the stakeholders assess the performance of the tasks/projects (A42). It is essential to review the project performance and then plan improvement actions to reach the next level of maturity.

Table 6.5: Activities in Evaluate and Improve

Code	**Input**	**Output**	**Control**	**Mechanism**
A41	Reports, handover documents	Feedback delivered	P-C-T	PO, PA, PP/PM, SC
A42	Feedback, evaluation criteria	Evaluation reports	P-C-T	PO, PA, PP/PM, SC
A43	Evaluation reports	Lessons documented	P-C-T	PO, PA, PP/PM, SC
A51	Lessons	Improvement action plan	P-C-T	PO, PA, PP/PM, SC
A52	Improvement action plan, available resources	Action performed	P-C-T	PO, PA, PP/PM, SC
A53	Lessons, improvement actions	Knowledge management	P-C-T	PO, PA, PP/PM, SC

The information feed-back system should be well organised to detect issues early and react to the issues effectively (A41). The collection of information in a centrally accessible repository would help eliminate information gaps caused by a high turn over of staff. Inputs of A41 could be MoE's templates and guidelines of what information needs to be collect. All issues, disputes, defects and responses to them during and after project implementation need to be informed to relevant stakeholders and recorded in the project file. All the feedback and information collected, then, will be the input of A42. The MoE's policies about performance evaluation guide the team about what needs to be evaluated, when the evaluated will be performed, and the methods of criteria of the evaluation. Evaluation reports are analysed by PA (or the agency), with support from SC, PP, and PM, to identify lessons from the completed projects (A43). Maturity model can

be applied at A42 to assess maturity level of each stage or the whole process. Outputs of activities in A4 and A5 can contribute to improvement of PMMS.

The feedback collection, performance evaluation and lesson analysis should be performed at the project level, regional level and portfolio level. Outputs of A4 are inputs to address a list of corrective and improvement actions (A51). PA (or the agency) lead SC, PP, and PM to take the corrective and improvement actions (A52). Time and resources need to be provided for the improvement. Once lessons and improvement actions are identified, knowledge should be captured by both the school and MoE (A53). A collection of reports, feedback, and lessons combined could form a knowledge management system for PMMS. The knowledge system should be organised and fit at school, regional and national level. Such a knowledge-based system would provide a data set of problems across all schools in NZ and offer solutions for the problems at the same time.

The knowledge system could also help MoE figure out what schools need the most, what tasks and at what schools money should be spent on, and quickly respond to any changes needed to implement their long-term strategy. Access to the system would also help SC or the agency compare their the maintenance workload with other local schools/team and find shared resources for solutions. People involved may share solutions, or quality contractors with each other.

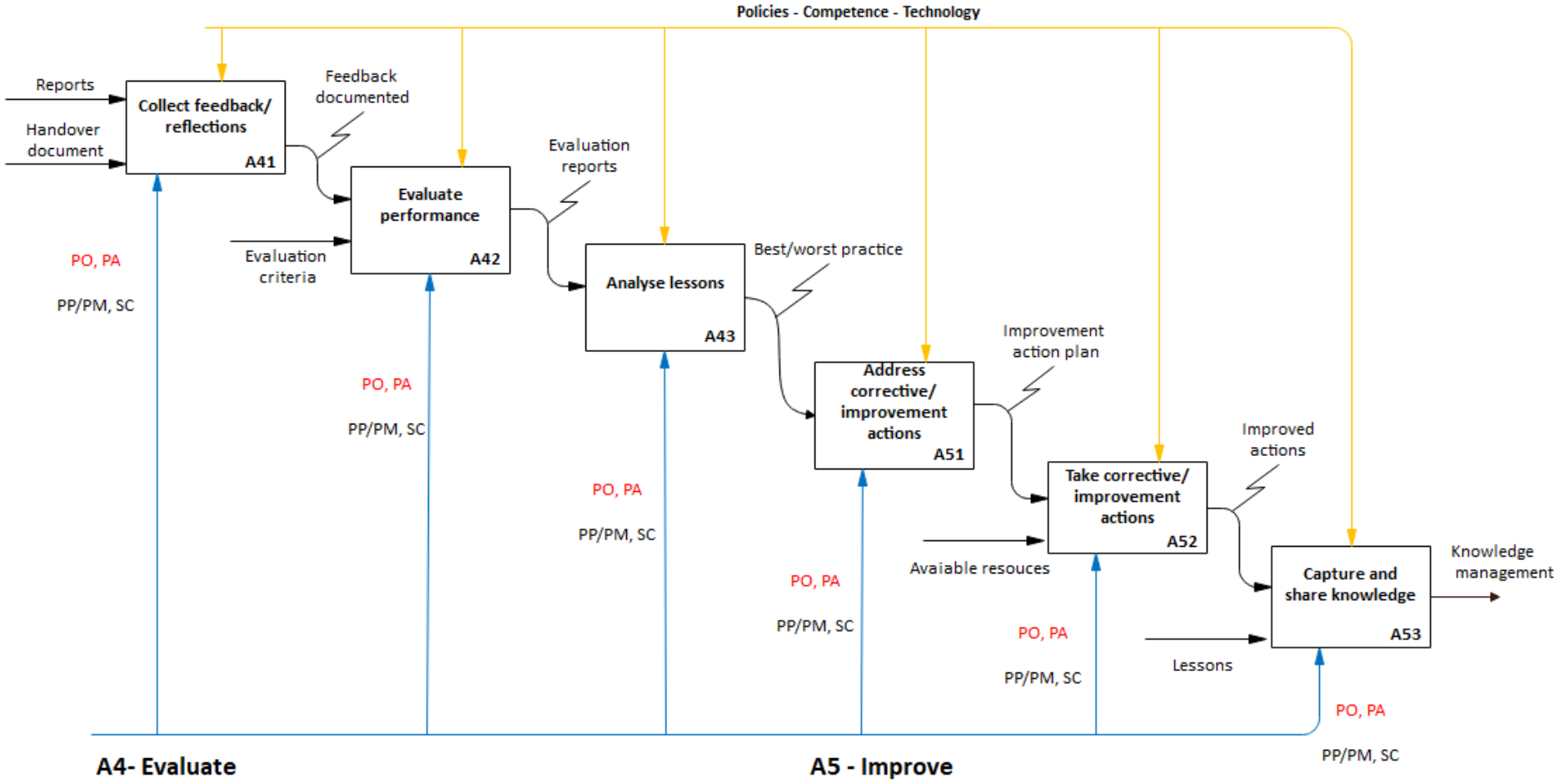


Figure 6.9: Evaluate and Improve stage in PMMS

6.4 Validation of the PIE Framework

The aim of PIE validation process is to examine the appropriateness of the proposed framework to improve performance of PMMS. This study consists of two stages: pre-validation discussions and validation interviews. Pre-validation discussions were conducted with three researchers at Massey University (1), National University of Civil Engineering, Vietnam (1), and Heriot-Watt University, UK (1), These pre-validation discussions were conducted to ensure that the interview questions are clear. Based on the researchers' comments, few changes were made to improve the clarity of presentation of the PIE framework.

The second stage involved interviews with eighteen school managers as the end-users of the framework. The validation interview template consisted of two parts. The first part was a description of the PIE framework and the relationships between the various activities in PMMS. The second part aimed to examine the clarity and appropriateness of the proposed PIE framework and identify a suitable strategy to implement it.

6.4.1 Interviewees' background information

The invitation was sent to people who expressed their interests to be involved in the validation process. The summary of the background of the 18 participants in the research is presented in Table 6.6. The participants were coded into two group: primary schools (R1 to R9), and secondary schools (S1 to S9) and were sorted according to the time of the interviews.

Thirteen participants were principals/deputy principals who were in charge of property management at their schools. The rest of the participants were three property managers and three business managers who were responsible for property management at their school. Nine of the participants have been working for over ten years in the area of school property management, and others have had at least two years' experience in their current position. Of the 18 participants, nine participants were working for primary schools while nine participants were serving at secondary schools.

Table 6.6: Validation interviewees' background

No	Code	Position	School Type	Student	Years of experience
1	S1	Property Manager	Secondary	1,001-2,000	over 10 years
2	S2	Property Manager	Secondary	501-1,000	5-10 years
3	S3	Property Manager	Secondary	1,000-2,000	over 10 years
4	S4	Principal	Secondary	501-1,000	over 10 years
5	S5	Principal	Secondary	1,001-2,000	over 10 years
6	S6	Principal	Secondary	201-500	2-5 years
7	S7	Principal	Secondary	501-1,000	5-10 years
8	S8	Business Manager	Secondary	over 2,000	2-5 years
9	S9	Business Manager	Secondary	501-1,000	5-10 years
10	R1	Principal	Primary	201-500	over 10 years
11	R2	Principal	Primary	Less than 200	2-5 years
12	R3	Principal	Primary	201-500	over 10 years
13	R4	Principal	Primary	Less than 200	2-5 years
14	R5	Principal	Primary	501-1,000	over 10 years
15	R6	Principal	Primary	Less than 200	2-5 years
16	R7	Principal	Primary	Less than 200	over 10 years
17	R8	Principal	Primary	501-1,000	over 10 years
18	R9	Principal	Primary	201-500	2-5 years

The background information also reveals the geographical distribution of the participants. Six participants were located in Wellington. Manawatu, Auckland, and Waikato had three representatives each. The Westcoast, Canterbury, and Marlborough regions were each represented by one participant. Of the 18 participants, eight worked at urban schools, five came from secondary urban schools and the remaining five were from rural schools. It can be seen that the participants were representative for different groups such as type of schools, years of experience, and location.

6.4.2 Validation results

The first part of the interviews consisted of questionnaire type questions. The respondents were asked to rate their level of agreement with statements on the

logic and clarity of the PIE framework from 1 (strongly disagree) to 5 (strongly agree). The results are displayed in the Table 6.7, which indicates that the majority of the respondents (above 90%) either "agree " or "strongly agree" with the logic and clarity of the framework.

Table 6.7: Logic and clarity of PMMS framework

Statements	**1**	**2**	**3**	**4**	**5**
1. The structure of the proposed framework is clear	0	0	0	77.8%	22.2%
2. The contents presented in the framework are precise	0	0	5.6%	61.3%	33.3%
3. It is easy to follow the processes and sub-processes of the framework	0	0	5.6%	61.3%	33.3%

During the validation interviews, most of the participants agreed that the structure of the proposed PMMS framework as well as its contents and processes are clear and logical. An interviewee mentioned:

..."I think the logic of the framework is clear and it is easy to follow the processes, so I strongly agree. The boxes and arrows are specified and simple to follow..."(R1).

Two participants (S2 and S7) held a neutral view about the contents presented in the framework and the ease of following the processes. S2 stated that when she looked at the framework, she did not follow the processes or contents in the process. However, if someone explained how to read the diagram from the beginning as the researcher did, it was easier for people to understand the whole diagram. S6 suggested that the framework should have a detailed guideline to explain every step in the diagram and help people understand how to use it.

The next questions were to evaluate the functions of the PIE framework. The respondents were asked to rate the level of agreement for the functions of the framework from 1 (strongly disagree) to 5 (strongly agree). As shown in the

Table 6.8, the majority of the respondents (above 80%) rated either "agree" or "strongly agree", confirming that the framework can help schools manage their property more effectively.

All participants rated the statement that the proposed framework helps the people involved understand the processes and activities, along with their requirements, with either "agree" or "strongly agree". Following are some of the comments taken from the interview transcriptions:

"...people know where they are at the moment, who they collaborate with and what they expected after each process..." (R5).

"...for me, the framework clearly identifies the roles in each activity, and the roles are linked in the framework to help the communication..." (S9).

In the next question, the respondents were asked to rate the appropriateness of the maturity assessment model. The majority of respondents accepted that the model can assess the maturity level of PMMS of individual schools, while R2 and R7 held a neutral.

Similarly, for the statement about the function of improving the efficiency of PMMS, R7 and R9 held a neutral view, but 16 of 18 participants expressed the belief that the framework can help improve overall efficiency of PMMS. A selection of participants' comments about the framework are presented below:

"...I have never rated 5 points, so I go with number 4, but I can see that the framework can help the players understand their roles, their relationships. It also address the weakest points by doing the evaluation, so it will help the improvement..." (R3).

"...The framework would definitely help schools and their property board managing their property effectively, but I'm not sure how the framework helps other actors in the framework, so I chose number 3..." (R9).

Table 6.8: Functions of the framework

Statements	**1**	**2**	**3**	**4**	**5**
1. The proposed framework can help property people understand processes, activities and requirements of the property and maintenance management	0	0	0	72.2%	27.8%
2. The maturity assessment model can identify the maturity level of PMMS	0	0	11.1%	50.0%	38.9%
3. The proposed framework can help improve overall efficiency of PMMS	0	0	11.1%	50.0%	38.9%
4. The proposed framework can help identify high priority areas for improvement of PMMS	0	0	5.6%	55.5%	38.9%
5. The framework helps improve collaboration of the stakeholders in PMMS	0	0	11.1%	66.7%	22.2%

V16 was the participant who held a neutral view for the statement that the proposed framework can help identify areas of high priority for improvement. R9 further explained this rating as she has just become a principal in the last two years and she has not had many chances for taking improvement actions for PMMS at her school. Other participants gave either "agree" or "strongly agree" for this function. One interviewee explained their position further:

"...the framework has a feedback loop and the evaluation so that's definitely important. So I give it a five..." (R5).

For the last statement of the framework functions, 16 of 18 respondents confirmed that the proposed framework can help improve collaboration of people involved in the PMMS delivery. S4 and S7 were the two respondents who held a neutral view and they both agreed that the collaboration more depends on the MoE's policies rather than the schools.

6.4.3 Advantages and improvement of the framework

To further assess the potential implementation strategy for PIE framework, participants were asked six open-ended questions to encourage a discussion on how the framework could be implemented. The first question was *"What do you consider the main advantages/main improvements of the framework in comparison with the current practice?"*. All respondents addressed different advantages of the proposed framework and their answers were categorised into three groups as described below:

Representation of the framework: Boxes and arrows help improve visual representation of the PMMS process and help people easily understand the flow of the different stages. Thirteen participants pointed out the potential of the framework to identify areas that need to be improved. Some of the comments are presented below:

"...It's not too complicated. Everything seems to be in its place. It has a sense of ability in steps to achieve a goal..." (S1).

"...the main advantage is that it's very clear and easy to understand, and you can see the horizontal processes. It relates well to each stage of that model. I think that's a big improvement. For new principals, it is very straightforward for them to understand this is what needs to happen..." (R1).

6.4.3.1 Improving collaboration:

Twelve people mentioned that the PIE framework clearly defines roles, responsibilities, and relationships of those involved, which helps improve collaboration between the key stakeholders. The processes in the PIE framework are clearly presented and easy to follow. Some of the participants elaborated on their thoughts as presented below.

"...this model will help them (the stakeholders) understand where they fit in the big picture and who the other players are and how important it is that they work well with them..." (R3).

"...I think the process is transparent. People know what is happening and what happens next and who's got responsibilities. Another advantage is those diagrams linked everyone together. So we're all on the same page. Because sometimes different people going on in different places and it's hard to understand or work together..." (S5).

S3, R6, R7, R8, and R9 mentioned the same keyword as V9 did. They all agreed that the key for successful collaboration is "people are on the same page" and that that was one of the contributions of the PIE framework.

6.4.3.2 Promoting continuous improvement:

Collecting feedback is an incredibly important way to improve. The PIE framework encourages stakeholders to collect, review, and evaluate feedback at any stage. The outcomes of this review provide opportunities for improving individual processes where necessary. Ten respondents mentioned "evaluation" as one of the advantages of the PIE framework. R1 reported:

"...I would say the evaluation step is the key improvement as its important in the framework. In our school, we do some evaluation but not systematically, just verbal in our meeting with school board members...." (R1).

V4 made a similar comment, saying that: *"...evaluation is not actually currently happening and I think it is the key improvement of the framework..."*.

Some interviewees thought that the ongoing training programme included in the Establish section ensures that the people are all on the same page. In reporting the above, one interviewee stated:

"...the training staff development makes sure that everybody fully understand the process and their place within the process, and also improve the accountability. I think that's really important...." (R4).

S6, R3, and R8 highlighted that the maturity assessment model is the key improvement of the framework as it allows to prioritise the improvement. The continuous improvement programme requires resources and efforts to follow a strict and planned schedule. Instead of combining multiple steps, the maturity assessment model addresses the most needed improvement areas, which help both MoE and schools avoid potential problems caused by a change in management.

6.4.4 Barriers of implementation of the framework

The next question respondents were asked in the validation interviews was if they could see any potential difficulties or barriers for putting the framework into practice. Despite their differences with regard to the length of their work experience and the type of location of the school they are working for, they all mentioned one of the two difficulties for using this framework in practice as below:

6.4.4.1 Resources:

Thirteen comments from the respondents stated that human resources, including lack of time, might be a barrier for the implementation of this framework. "Understanding", "training", "right people" and "more money" were mentioned many times in the answers for this question. The framework requires people to share the same vocabulary, understanding, vision, and aims for PMMS at their school and examples illustrating this point are provided below:

"...we would need to put a lot of effort into the staff development so that everybody's on the same page and has a clear understanding how the framework works..." (R4).

"...there's not enough resources at the moment. So more work or more communication, more collaboration would be very difficult with the number of people that they seem to have..." (S6).

"...all the people should be on the same page. And make sure that training is ongoing. So it's not just one off for one person, it's got to be a team and it's got to be reviewed and renewed constantly because people forget and they go back into old ways..... (S9).

"...the people would need more time to become familiar with the process or more training to do the evaluation (R2).

R2, R3, R6, S3 and S5 on the other hand, believed that money would be the greatest challenge for the implementation of the framework as they could see that it takes more time and effort to upskill people and increase the communication among them. They also stated that their schools would need more support should this framework be adopted for the management of their properties. This point is raised by S3 in the excerpt below:

"'...we need more people to do the evaluation and review, currently we have no time for it. So we need more financial resources

6.4.4.2 Willingness to change:

S1, S9, R3, R5, and R8 held the view that *"resistance to change would be the biggest challenge"* for the implementation of the PIE framework. Lack of competence, low trust, poor communication, and lack of commitment were the reasons mentioned by the respondents for the potential resistance to change. Participants also commented that, while school may be interested in implementing the framework as it promises to benefit them, the MoE staff may prefer to leave things

are they are because the new regime would increase their responsibilities and workload.

6.4.5 Likelihood of using the framework

The respondents were asked one more question about *"How likelihood is that you would use the PIE framework to support your school in PMMS?"*. Ten participants said that they would probably adopt the whole framework or particular steps/processes related to the processes they are involved in. Eight participants stated that they would definitely use the framework in order to improve the effectiveness of PMMS at their schools. S2, S3, S9, R2, and R5 especially would like to adopt the activities from the Evaluation and Review stages for their internal improvement.

The respondents also discussed the incentives for implementing the PIE framework. The participants proposed that at the school level, a benefit of introducing the proposed framework was that it would help increase an awareness of the long-term PMMS strategy among school board members in managing their properties. Although schools would also need support from other stakeholders in implementing the framework, the interviewees believed that school can use the framework immediately as a guidance for their internal improvement. Several recommendations were suggested by the interviewees to facilitate wider adoption of the framework, including:

- Develop a user guide that provides definition of terms and a set of template documents for specific actions, such as a evaluation performance form (A42);
- Propose assessment performance criteria for 5YA projects and maintenance work (A42);
- Suggest list of common improvement actions (A52) and knowledge sharing methods (A53).

The recommendations were considered and the PIE framework can come with a set of documents as suggested. At the national level, the framework would need to be approved by the MoE and then officially introduced to all stakeholders. This part is not covered in this study as the primary aim of the present research is to focus on helping schools manage their properties. Suggestions for future research is discussed in Chapter 8.

6.5 Summary

This chapter presented the design and development processes of the PIE framework and provide evidence that the framework could be used in practice to help schools manage their properties.

The findings of the preliminary study, interviews and questionnaire survey revealed the challenges and maturity level of the current PMMS. Based on the results, a new PMMS framework was developed with five stages: Establish, Plan, Implement, Evaluation and Review. Each stage consists of several activities and the activities are displayed by boxes and arrows using IDEF0 modelling language. Input, output, control, and mechanism are mapped for each activity, providing a detailed and clear process for the users.

The framework was validated through online interviews with school managers. Based on the validation interview results, the overall view regarding the clarity and appropriateness of components in the proposed PMMS framework are positive. All interviewees would like to adopt either the whole or a part of the PIE framework in their work. The interviewees also put forward some recommendations to encourage a wider adoption of the PIE framework, such as developing a user guide, and providing template documents. The validation results indicate that the PIE framework could be used in practice.

Chapter 7

Discussion

7.1 Introduction

This chapter presents a discussion of the significant research results, and then reviews them with reference to the relevant literature. The first section discusses the importance of property and maintenance management for NZ's state schools. The improvement of PMMS using the PIE framework will be discussed by addressing challenges in the existing framework. Discussions of an flexible organisational approach and a cost plan for effective maintenance management are followed. Barriers to implement the PIE framework in practice are discussed an solutions also are suggested.

7.2 Importance of the research

Asset management is critical for any organisation in any country as it involves making use of resources for optimal performance of the assets. Property management and maintenance management are important scopes of asset management, which help deliver the best service for built assets. The literature reveals that there were many frameworks developed for property management, maintenance management, and asset management (Hackman, 2008; Macchi et al., 2011; Márquez, Díaz and Fernández, 2018; Martin and Black, 2006; Mirghani, 2001). The models and frameworks offer guidance to provide better performance of maintenance services and and property management and at the same time maximise the value of the investment. However, the literature also suggests that organisations need to understand their context, resources and constraints to develop an

appropriate asset management framework.

In NZ, the state school portfolio is the second-largest public asset portfolio, which manages over 2,000 schools across the country (Ministry of Education, 2017). Previous studies proved that conditions of physical schools play important roles in providing a safe and pleasant environment for teaching and learning (Trachte and De Herde, 2015). Therefore, there have been many attempts to conduct research on maintaining school property. Literature also provides evidence of the benefits of collaboration paradigms over the entire life cycle of the built asset, not only in design, and construction phases, but also in managing the existing buildings (Bouchlaghem, 2012). However, merely bringing a group of participants to work together does not ensure the success of collaboration. It is critical that all people involved clearly understand about their roles and responsibilities and how to collaborate to achieve the common goals (Ampofo et al., 2020). However, a small number of attempts was made to establish models to examine relationships among key stakeholders in relation to promoting the improvement of property and maintenance management in NZ's state schools.

This research firstly investigates common challenges and weakest areas in PMMS. Findings revealed that PMMS requires the collaboration between stakeholders on both strategic (development of long-term plans) and operational levels (implementation of approved projects and maintenance). Since different parties are involved in developing the plan and implementing the projects, a high level of collaboration at both levels is a critical factor for ensuring the success of the management system. The key findings emerging from the research were embedded into proposed PIE framework. The PIE framework aims at highlighting the different roles of the key stakeholders in every activity in delivering PMMS. Evaluate and Improve are designed to be completed at anytime in the PIE framework to help collect feedback, share lessons and make improvement. All identified challenges in this study are addressed by using the PIE framework.

7.3 PIE framework for PMMS

7.3.1 Addressing challenges in existing framework

Findings from Chapter 4 and Chapter 5 investigated the challenges and the weakest areas in PMMS, which need to be addressed in the proposed framework. Both

the challenges investigated from the interviews and weakest areas identified from quantitative data analysis are found to be interrelated when considered together.

7.3.1.1 Establishing a shared vision

Findings from interviews highlighted that due to the key stakeholders being based in different organisations, having different interests, and performing specific short term tasks, they lack of a shared vision of PMMS. This poses great challenges to manage the school property. This finding is inline with **?** who revealed that managing infrastructure assets involving multiple stakeholders ranging from the asset owners, asset managers, and asset users with various requirements and expectations is often the biggest challenge. Abdelhamid et al. (2013) also claimed that goals and objectives of asset management for educational buildings are often not clear enough and is not understood by all stakeholders.

Bouchlaghem (2012) stated that a shared vision should be agreed by all parties that helps plan and manage tasks and activities in the right direction. This view is agreed by Meng et al. (2011) who stated that common vision and mutual benefits ensure successful collaboration in construction. This finding is in line with previous studies that have stressed the importance of having a shared vision is the key driver for collaboration (Akintoye and Main, 2007; Koolwijk et al., 2018). Therefore, in the PIE framework, establishing a shared vision is the key output of the Establish phase to ensure that all people involved are performing their tasks towards the common goals of PMMS.

As shown in Figure 6.5, understanding PMMS goals, and objectives, understanding school's needs and wants, understanding roles and responsibilities and competencies of people involved are inputs of establishing a shared vision. This idea is supported by Jensen et al. (2019) who argued that mutual understanding can create a shared vision and promote working as a team. Kamarazaly (2014) agreed that by articulating a shared vision, top management is able to ensure the value and long-term adaptability of the educational facilities. This finding is somewhat consistent with Hackman (2008) who emphasised the gaps between the strategic and operational levels could be minimised by a shared vision which can help enhance the improvement of maintenance operation processes. A shared vision can be established by clearly defining roles and responsibilities, attending training courses, and promoting communication and commitment. Outputs of activities in Establish, as presented in Table 6.1, will contribute to improving

moderate and high priority areas such as PO1 (long-term strategy), PO2 (policies), PO3 (communication), PO4 (roles and responsibilities), and PO5 (training programmes).

Findings of this study also emphasise the importance of facilitating engagement and communication between the people involved in the PMMS (PA3, PA7, PO3). These findings are consistent with Reymen et al. (2008) who found that the success of a process depends on the level of cooperation between the actors. Stakeholder communication plays a crucial part in ensuring maintenance strategies are carried out as planned (Salah, 2016). This view is also shared by Lang, Dickinson and Buchal (2002) who argued that success of collaboration requires effectiveness of communication and engagement. Hackman (2008) acknowledged that interactions between top management at strategic levels and maintenance personnel at operational levels are powerful for influencing performance of maintenance activities. Therefore, in the Plan and Implement phases, the first activity suggested in the PIE framework is engagement of people involved in these phases (A21, A31) to develop an agreed standards, procedures, goals and objectives. Outputs of this activity ensure that people have common goals and will help reduce conflicts in the implementation.

7.3.1.2 Increasing capability and human resources

Quality of workmanship, including training, awareness, and competence of employees, has a significant influence on the effectiveness and efficiency in the built environment (Adeyeye et al., 2013; Ling, 2004). Lewis et al. (2010) stated that trained and knowledgeable staff are critical for maintaining high performance buildings. The specific skill set of each role should be clearly defined. Other researchers confirmed that the key factor ensuring the success of property and maintenance management is the collaboration between the people involved in the process (Bouchlaghem, 2012). This is fairly consistent with Dulaimi et al. (2007) who agreed that understanding individual roles of the partners and their abilities is critical factors for the success of collaboration in the construction industry. This view is shared by Repetti and Prélaz-Droux (2003) who identified individual capabilities and coordination of all key stakeholders as driving factors in improving the efficiency of maintenance management. In other words, knowledge, competence and teamwork have a significant impact on asset management outcomes (The Institute of Asset Management, 2015).

In PMMS, each activity is a complex task and is achieved by combining the abilities of people in a team so the success of PMMS largely depends on capabilities of the team. Therefore, the competence of people doing tasks is important for the achievement of the collaboration. However, it is proven that school boards lack capability in maintenance management as evaluated by PA (see Figure 5.6). Participants in the interviews also claimed a lack of qualities and skills of PA, PP and PM. The maturity level scores of PA3, PA6, PA7, PP4 strongly suggest that there is a need to increase people capability of carrying out their roles in PMMS.

The organisation should determine the necessary competence of staff and job requirements to provide appropriate education and training to acquire the necessary competence (ISO 55000, 2014). In the PIE framework, implementation of the training programmes (A14) will provide a long-term professional development program for people involved. It should not be an on-off training; it should be an ongoing training program. An online-based training system should be considered due to the different locations of the stakeholders. The online-based training systems could help the Ministry to update the information quickly and participants could review the sessions at any time. The online-based training system could also act as a communication channel, where PA, PP, PM, and SC could share their experience and improve the trust and engagement in the collaboration. Literature reveals that staff training and development is found to have a critical impact on workforce empowerment and productivity (Au-Yong et al., 2017; Kamarazaly, 2014; Muyingo, 2009). Many researchers agreed that communication flow and feedback systems can lead to a better teamwork and job satisfaction (Newig et al., 2008; Rahmat and Ali, 2010). In the PIE framework, implementation of activities in Evaluate and Improve phases enables the key stakeholders to evaluate their performance, share best/worst practices, and therefore, identify what skills are required and what sorts of training are needed to develop an efficient staff.

7.3.1.3 Improving data capture and information management

Kelly et al. (2005) suggested information is essential at all stages of asset management. Information management is also needed to improve transparency and reduce conflicts throughout the duration of collaboration (Shelbourn et al., 2007). Information technologies including tools and software have been introduced to

strengthen the interaction of stakeholders and manage the information and knowledge exchange. Moreover, knowledge in the operational phase can be transferred in new building projects which help the project team produce long-term beneficial decisions (Jensen et al., 2019). However, the interviewees indicated that there is no well-structured data capture guidelines and information management system in the current model. There is also a lack of IT support for collecting the feedback. Moreover, results from quantitative data show that PO8 (reporting system), PA6 (sharing knowledge and lessons) and SC9 (feedback collection) are in need of improvement. These findings are fairly consistent with Parlikad and Jafari (2016) and Abdelhamid et al. (2013) who emphasised that data capture, data sharing and data standards are major challenges in asset management.

In PMMS, the critical challenge for the state school property sector is that there are more potential tasks to implement than resources and budgets will allow, which requires proper decision making and prioritising of tasks. This finding is inline with Au-Yong et al. (2017) who argued that stakeholders should focus on information sharing in maintenance management. Accurate and adequate information about the property condition and its performance enables managers to make informed and practical decisions in planning stage. This view is agreed by Parlikad and Jafari (2016) and Muyingo (2009) who stated that using historical and real time data can reduce costs, risks and failure in asset management. In the PIE framework, at the beginning of each project, a project file is created to collect, store and update all relevant information (A32). This file includes all required reports and confirms what type of information should be collected, stored, and shared during the project implementation. At the end of each project (A35, A3'5), the data collected can be used for evaluations. At school level, it is important that schools continuously record and update their maintenance information and report this information to the MoE (SC8). Relating information is important to perform maintenance task properly (Gómez-Chaparro et al., 2020), and make decisions for future renewal alternatives such as renovation or refurbishment. Therefore, both the MoE and schools should pay attention to the information management of all maintenance work and provide the information for other stakeholders if required.

7.3.1.4 Leveraging knowledge capturing and continuous improvement

Findings from interviews reveal that there are no official performance evaluation activities in the existing model. Results of quantitative data also indicate a lack

of performance evaluation framework for PMMS (PO6), and there has not been attempt to collect feedback, and share lessons at both the school level (SC9) and the regional level (PA6). The performance evaluation should not only conducted at the project level, it should be implemented at a regional and portfolio level to inform policy makers. These findings are consistent with ISO 55000 (2014) and PAS 55 (2008*b*) which highlighted that performance assessment and improvement are critical parts of the management system structure. Previous studies emphasised that issues such as loss of gained knowledge, and repetition of mistakes can lead to additional expenses and resource waste in building maintenance (Almarshad et al., 2010; Talamo, 2016). Therefore, evaluating the performance is to ensure that the processes have been carried out as planned and the outcomes meet the stakeholders' expectations. The information collected in these evaluation processes will generate lessons and knowledge supporting the decision-making process (Jensen et al., 2019; Motawa and Almarshad, 2013).

In PMMS, although there is a centralised system of information at the Ministry level, some interviewees found that the systems are not easy to access, and commented that there is no official guideline on what information needs to be kept, recorded, or monitored nor is there any real structure for how property information is managed and shared. The maturity level results also indicate that reporting systems (PO8) and information and knowledge management (PA6, SC8, SC9) are in need of improvement. In the PIE framework, it requires to develop a guideline for gathering reports, feedback, and lessons during and after each project in PMM (A4 and A5). The reports, feedback, and lessons together can build a knowledge management system for PMMS. The computerised knowledge-based system provides a data set of problems across all schools in NZ and the solutions for the problems accordingly. Recently, many frameworks have been introduced to manage the information and knowledge exchange that help improve collaboration in project management (Kadefors, 2007; Pee and Kankanhalli, 2009). Many researchers proposed a knowledge management system for building maintenance organisation (Ali et al., 2004; Fong and Wong, 2009; Lepkova and Bigelis, 2007). Most of the knowledge management systems are web-based applications that collect staff's experiences, decisions and knowledge. Knowledge can be exchanged and shared thanks to the database, and information system to improve the decision making process (Gao et al., 2002). In this PIE framework, knowledge can be transferred according to communication and interactions of key

stakeholders by implementing activities in Establish, A31 and A3'1 in Implement. This finding is in line with Jensen et al. (2019) who emphasised that knowledge transfer within an organisation relies on collaboration of people involved.

7.3.2 Flexible organisational approach for maintenance management

Findings from the interview revealed that different schools have different titles for people who are responsible for maintenance management at their schools. In primary schools, principals usually are are responsible for managing maintenance tasks. Primary schools do not employ a full-time staff member with appropriate training and qualification for maintenance management due to limited resources. Secondary schools often have property managers or business managers who manage the property and maintenance management at their schools. Therefore, school principals in the primary schools claimed that there is a lack of resource for maintenance management because it involves a lot of time consuming tasks and this is the most pressing management task for them, especially for the new principals. The quantitative results also indicated, as shown in Figure 5.6, that PA evaluated SC4 (ensuring maintenance management complies with legal and MoE requirement), SC6 (ensuring day-to-day maintenance of school buildings and infrastructure) are below level 3, while the maturity level of PA6 (supporting schools in resolving their property issues) and PA7 (helping schools improve their maintenance management) are below level 3. This means the people involved in the maintenance management has not performed their roles effectively.

To solve the issue of lack of abilities in maintenance management, a consideration of a centrally managed model at a regional level might help for schools which struggle to maintain their property, as shown in Figure 7.1. Using the PIE framework, schools are able to determine (at A13) if they are capable of managing maintenance management or moving to the centrally managed model.

The agency can be a group of skilled personnel, working at sub-region, or provincial level. It may be better to use the experience of an existing agency, rather than to establish a new one. Therefore, the team should be headed by PA with the additional staff (PP, PM) and facilities need to enable the work to be effectively executed. The number of staff should be determined depending on the number of schools in the region/province. This group will control all of the

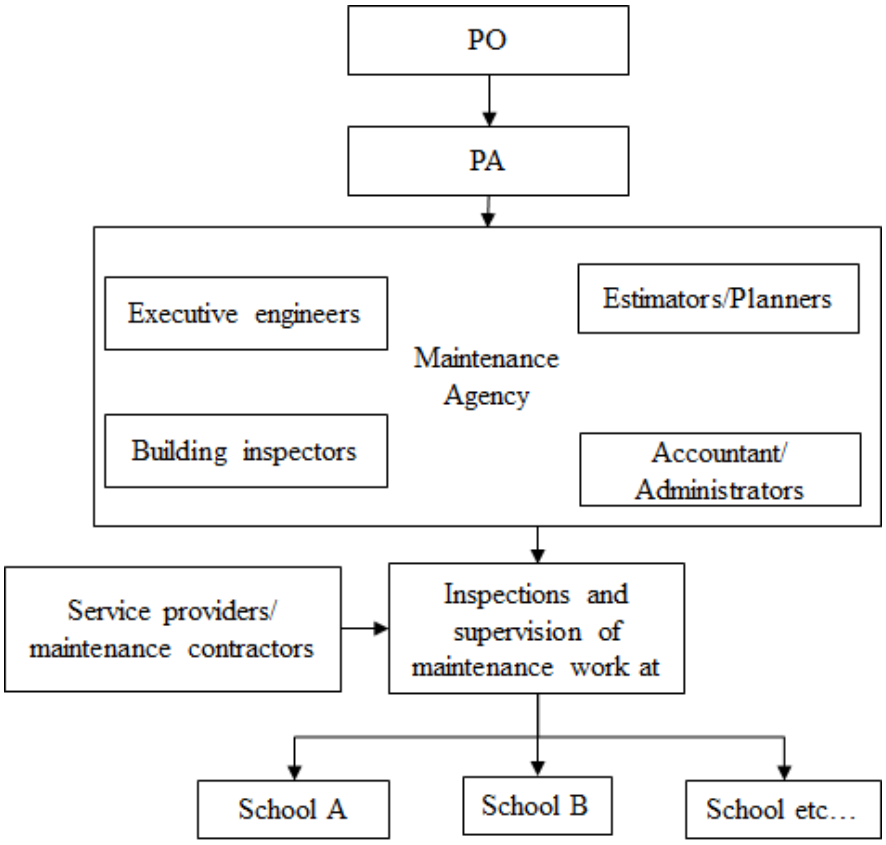


Figure 7.1: Centrally managed model

functions including building inspection, estimating, contract and general administration. This group is headed by a PA, who already understand the existing system and should have a background on engineering or asset management. This group would be included with one or two inspectors, who can visit and survey schools on a monthly basis and review schools' reports on a weekly basis. In addition, there may be one cost estimator who would be able to communicate with contractors, prepare contracts and make payments to contractors; and one administrative staff who would be responsible for general administration tasks. This approach is appropriate for a group of small schools or schools in rural areas.

Another concern regarding human resources is the lack of property people in primary schools. It is also difficult to find project managers to manage the property projects in schools in rural areas. The reason for that was that the primary schools have less extra income to cover the wages of a full-time property manager to help them manage their property. A model of resource-sharing should be introduced for small schools that might need. A group of neighbouring

schools can employ one property manager who is responsible for property matter at all schools involved. As the workload in the small and rural schools is not very heavy, a shared property manager should be able to manage the maintenance work of several schools. When a property manager is employed for several schools, all school can contribute to the manager's wage. By doing that, schools would have access to a fully qualified yet more affordable property person to help school boards make the right decision for maintenance management. Instead of establishing a new team, a resource-sharing model might help those schools are in need of having property specialist but not affordable for employing a full-time property manager on site.

These findings of this study are consistent with The Institute of Asset Management (2014) who state that there is no one correct structure for asset management that would be suitable for every type of organisation. Each organisation needs to decide the most appropriate approach depending on their context and resources. This argument is supported by Haroun and Duffuaa (2009) and HajShirmohammadi and Wedley (2004) who developed organisational alternatives for maintenance management including centralised, decentralised, semi-centralised, or a hybrid approach. Each approach has its own advantages and disadvantages. and the selection of the most suitable one depends to a greater extent on the maintenance workload, capability of the team, and the philosophy of organisation. In PMMS, due to the huge difference between schools across regions, therefore, it is suggested to develop a flexible organisational approach for maintenance management at schools. School boards and MoE together determine which the best approach for every school: in-house, outsourcing, centralised, decentralised, or a combination approach. There is a need to further discussion advantages and disadvantages of these approaches and schools' preferences.

7.3.3 Developing a cost plan using information management system

The funding for maintenance in schools in NZ is typically limited and schools are required to achieve their property maintenance goals with fewer resources and constrained schedules. All interviewees confirmed that the funding allocated was not enough for their maintenance needs so their schools had to raise extra funding to cover the remaining parts. Inappropriate funding calculations which

are based on the size of buildings and number of students enrolled was mentioned by several participants and they also reported that the calculations hasn't been adjusted to reflect the actual needs at the school. The problem has been solved by the schools generating extra income, for instance through international students fees. However, not every school has international students. Other schools in this study confirmed that they had to cover the inefficiencies with other funding sources which should have been used for the development of learning and teaching activities.

The insufficient fund for maintenance prevents preventative and proactive maintenance in schools and unexpected maintenance demands are bound to arise. This argument is in line with Madureira et al. (2017) who claimed that about 75–80% of costs occur during the use and maintenance stage for a building. Therefore, it proves the importance of proper maintenance funding to prevent building deterioration and ensure the service life of a building. The Queensland Government also noted in their guideline for housing and public work that the departments must allocate sufficient funding in their maintenance budget to keep buildings well maintained (Queensland Government, 2010). Investment in maintenance may not bring revenue, but generates savings by increasing the life cycle of components/equipment or decreasing replacement cost, and retaining the value of investments in the property (Puķīte and Geipele, 2017). Therefore, a fair funding benchmark for maintenance that involves regular inspections and maintenance will minimise more expensive repairs in the long run and maintain the functional lifetime of building property and equipment.

If activities in Evaluate and Improve are performed effectively, there will be a database of maintenance cost at every school. These information can be used to develop a cost plan and structure for occupancy cost. Such a cost plan would provide a reference that helps the MoE to review the funding programme for maintenance. This cost plan and structure would also enable school managers to understand the average annual costs for each of the key maintenance tasks and help them prepare funding for these jobs. Building Cost Information Service (BCIS) published a report on maintenance and operating cost for secondary school buildings in 2018. The report provided an estimate of the total occupancy cost over a 20-year period for secondary school buildings in the UK. The cost plan included: planned maintenance, reactive and preventive maintenance, major repair and replacement, redecoration, cleaning, and ground maintenance

and external work. As listed in the report, a cost plan can (Royal Institution of Chartered Surveyors, 2018):

- be used for short-term and long-term budgeting in tactical or strategic planning
- provide a year by year budget for the maintenance cost of the buildings
- highlight the pattern of expenditure and necessary work that need to be carried out each year
- show where planned replacements of major items occurs within the building's life
- give instructions of setting out the work required and frequencies of each treatment.

A cost plan would make it is simple for school managers to prepare the maintenance plan for their schools, including full details of work required, and a budget for each item. The cost plan should be kept up to date to reflect changes in the work required or prices for equipment or services. A cost plan can also help the MoE review the funding models to ensure that the funding is sufficient for the maintenance needs.

Many researchers concern on developing maintenance cost estimation models (El-Haram and Horner, n.d.; Krstić and Marenjak, 2017; Le, Domingo, Rasheed and Park, 2018). Maintenance cost includes all costs of keeping the building up to an acceptable standard. It relates to the direct cost of maintenance such as spares, labours, equipment and tools as well as indirect costs such as administration, management and the inevitable overhead costs. Krstić and Marenjak (2017) produced the models basing on historical data of buildings in the University of Osijek to predict maintenance cost models over the periods, which used multiple-regression and Stepwise analysis to identify the relationship between the variables resulting in three models. This method was also employed by Li and Guo (2012) who established a cost prediction model of maintenance for university buildings in Taiwan that used historical data on maintenance to predict the model. The database of information should be updated regularly to be used in statistical analysis or simulation such as Monte Carlo method to estimate the uncertain maintenance such as failure by natural disasters. Previous studies have proven that maintenance cost model can be developed based on historical data and a cost plan is essential for managing existing buildings and infrastructure.

7.3.4 Control factors of PIE framework

All activities in Plan, Implement, Evaluate and Improve phases have the same control factors: policies, competence and technology. Control factors in IDEF0 modelling language define the conditions required to produce the correct output.

Most interviewees mentioned policies such as funding models and communication are control factors to success of the project delivery. Hypotheses testing results share this view as the results indicate that PO has a great influence on the maturity level of PA, PP, PM, and SC. This finding is in line with Abdelhamid et al. (2015) who argued that asset management policy reflects performance of an asset management system. The Institute of Asset Management (2015) recommended that asset management policy comprises the principles and mandated requirements which ensure that the defined objectives of asset management plan are achieved. In PMMS, policies established by the MoE are conditions to produce correct outputs of each activity including:

- financial resources and allocation
- qualifications, roles and responsibilities of people involved in PMMS
- accountability and channels of communication
- standard working procedures and monitoring
- performance evaluation and feedback systems
- information management

The second control factor identified from the interviews is the competence of the people involved. Competence is the ability to apply knowledge and skills to achieve intended goals (ISO 55000, 2014). Considering that activities in PMMS are achieved by combining the abilities of different people, it follows that the success of the projects in PMMS heavily relies on the competence of the individuals. The requirement of personnel's competence is also emphasised by the research findings of Talamo (2016) and Chanter and Swallow (2007).

Last but not least, the introduction of information and communication technology (ICT) including tools, software, and data warehouse were suggested to strengthen the interaction of stakeholders and manage information and knowledge exchanges. Because key stakeholders in PMMS are based in different offices, and they often do not interact in person, so a new version of the software

that can automatically retrieve digital information, store large amounts of knowledge and smoothly distribute information is critical to the success of the delivery of PMMS. Various studies have proposed integrated ICT solutions for the various project life cycle phases, including maintenance management (Chanter and Swallow, 2007; Motawa and Almarshad, 2013; Talamo, 2016). The information technology increases access to knowledge and information resources (Jensen et al., 2019), therefore, it is a crucial condition for implementation of activities in PMMS. The findings from data analysis and literature review confirmed that policies, competence and technology are conditions to produce correct outputs of activities in PMMS.

7.3.5 Barriers and solutions to implementation of PIE framework

Findings from validation interviews reveal barriers for implementation of PIE in practice. Improvement actions and their risks also summarised in Figure 7.2, 7.3, 7.4 and 7.5. The significant barriers can be categorised into insufficient resources and resistance to change. Regarding insufficient resources, discussions and solutions have been produced in sections 7.3.1, 7.3.2 and 7.3.3. This section only focuses on the resistant to change and motivations for development.

The PIE framework requires changes in the current processes, adding activities in the Establish, Evaluate, and Improve stages. The five participants in the validation interviews mentioned resistance to change would be the biggest challenge for the implementation of the PIE framework. Previous studies have proven that because of the dynamic environment and industry growth, organisations constantly experience change. They have to change themselves to succeed. Changes in organisations can be implemented successfully if they are accepted by their staff. However, resistance to change from the employees is inevitable (Erdogan et al., 2008), as changes bring alterations to the staff's duties, roles, and levels of influence. Organisations' managers should be aware of all sources of resistance to change and understand the reasons for the resistance in order to be prepared and manage the changes proactively (Rick, 2011). Understanding the stages the key stakeholders are going through during a all school need to contribute to the manager's wage and the reasons behind their resistance will help with the successful implementation of the PIE framework.

Activity	Challenges	Actions for improvement	Risks
A11 Establish policies	- Inefficient policies	Establishment of policies including: - Financial resources and allocation - Roles and responsibilities of people involved - Accountability and channels of communication - Standard working procedures and monitoring - Performance evaluation and feedback systems - Information management	- More resouces for changing the current model - Resistance to change
A12 Understand policies	- Lack of mutual understanding of policies	- Providing training - Facilitating communication	- Resistance to change
A13 Understand school's needs and wants	- Inconsistent school development plan - Lack of experience and interests of school board on maintenance management	- Providing training - Facilitating communication	- Resistance to change - Motivation for development
A14 Attend training	- Lack of training programmes	- Providing training - Introducing online training sessions	- ICT problems - Motivation for development
A15 Understand roles and responsibilities	- Rigid organisation structure - Lack of clear responsibilities	- Providing flexible organisational approach - Providing matrix of roles, responsibilities, and accountabilities	- Maintaining a balance between the interests of all stakeholders
A16 Establish a shared vision	- Lack of mutual understanding	- Providing training - Facilitating communication	- Resistance to change

Figure 7.2: PIE Implementation - A1

Activity	Challenges	Actions for improvement	Risks
A21 (A31) Engage people involved	- Lack of trust - Lack of ICT support	- Providing training - Facilitating communication by identifying who, why, when and what of communicating	- Resistance to change - ICT problems
A22 Conduct condition assessment	- Lack of historical data - Lack of specialist	- Updating information system and database - Resource-sharing	- More resources
A23 Prioritise projects and estimate budget	- Unrealistic budget - Lack of specialist	- Introducing a cost plan/cost estimation model - Providing training	- Resistance to change - ICT problems
A32 Initiate project	- Lack of standardised procedures - Lack of specialist	- Providing templates, requirements - Resource-sharing	- More paper work
A34 Close project	- Lack of project handover documentation - Lack of ICT support (data capturing, data management)	- Providing templates, requirements - Introducing new technology supporting reporting, data capturing and management	- More resources - ICT problems - Staff's capabilities

Figure 7.3: PIE Implementation A2, A3

Activity	Challenges	Actions for improvement	Risks
A31 Engage people involved	- Lack of trust - Lack of ICT support	- Providing training - Facilitating communication by identifying who, why, when and what of communicating	- Resistance to change - ICT problems
A3'1 Develop maintenance cost plan	- Lack of historical data - Lack of specialist - Lack of ICT support (data capturing, data management)	- Updating information system and database - Resource-sharing - Introducing new technology supporting reporting, data capturing and management	- More resources - ICT problems - Staff's capabilities
A3'2 Finalise maintenance tasks	- Lack of funding for maintenance - Lack of experience and interests of school board on maintenance management	- Introducing a cost plan/cost estimation model - Providing training - Providing a centrally managed model	- More resources - Resistance to change
A3'3+A3'4 Schedule and carry out maintenance	- Lack of experience and interests of school board on maintenance management - Lack of service providers and contractors in remote schools	- Providing training - Providing a centrally managed model	- More resources - ICT problems - Staff's capabilities

Figure 7.4: PIE Implementation - A3'

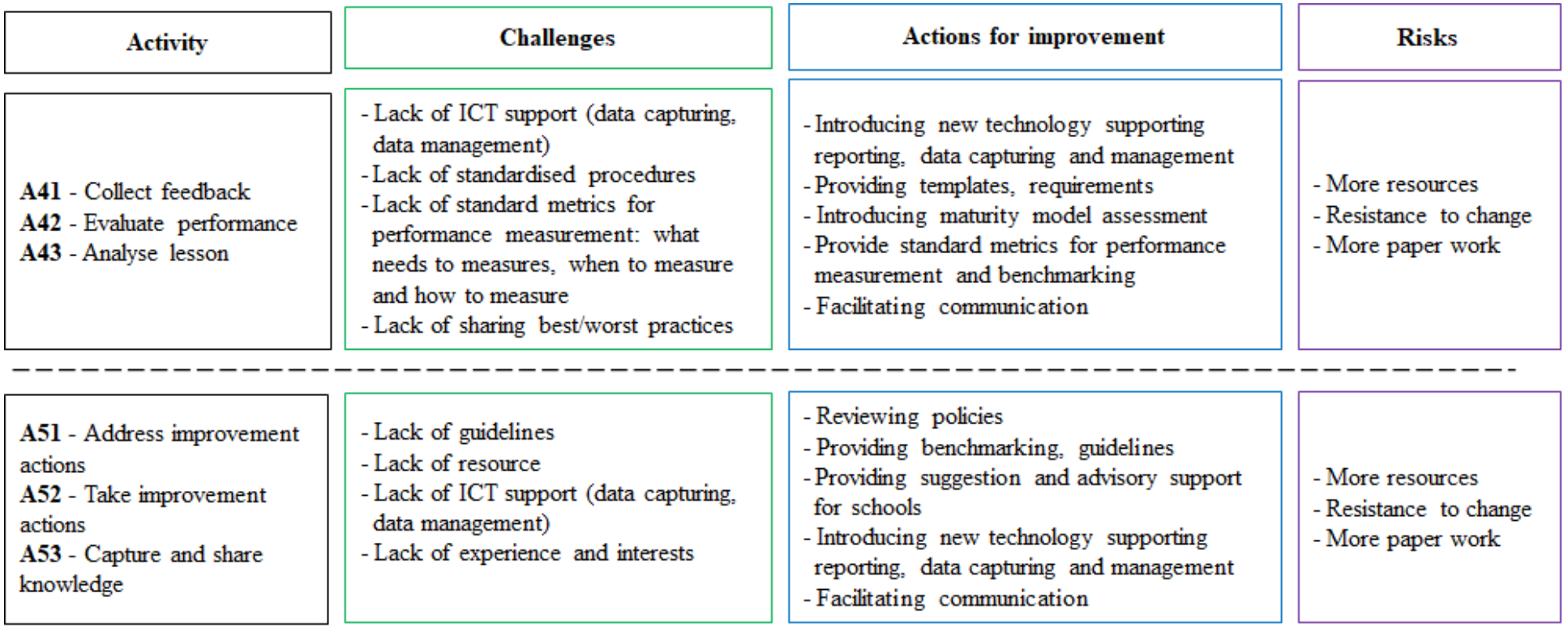


Figure 7.5: PIE Implementation - A4, A5

Reasons for resistance have been studied by many researchers who found them to be related to the following areas: misunderstanding about the need for change, lack of competence, poor communication, and low trust (Burnes, 2015; Erdogan et al., 2008; Hon et al., 2014; Rick, 2011). The first reason is a lack of belief or understanding of the need for change. Especially from those who strongly believe the current processes are working well have no motivation for change. An explanation for why the change is needed and important for the organisational development might help these staff understand the big picture and benefits of the change. It is better to get the staff on board with the change and help them understand the stages that they are going through during a change. In PMMS, activities in the Establish phase (understanding policies, procedures, roles, responsibilities and communication) and the feedback loop in the Evaluate and Improve phases will help key stakeholders understand where they are and will happen next.

Change in organisations usually requires staff to learn new skills. And one of the most common reasons for resistance is lack of competence for the new role they are required to fill (Rick, 2011). People will only take active steps of moving forward in a new direction if they are well prepared for fulfilling their new roles. Staff training and development would help overcome this resistance. In this research study, staff training was also identified as a high priority for improvement (PO5). As a result, training programes (A12) was added to the Establish phase.

Poor communication is another reason why employees oppose change (Rick, 2011). Communication helps employees understand why there is a need for change, what the benefits are and what they need to do to prepare for the change. The findings of this study show that more communication among the key stakeholders is needed in order to explain benefits of the new PIE framework and to share the goals and expectations for the implementation process. Erdogan et al. (2008) argued that a lack of trust in the people managing the change causes staff to resist change. Staff can only follow the changes if they believe in the leadership and the leadership is capable of making change happen. A transparent process and known procedures for all the people involved can build trust and help implement the proposed changes (Bouchlaghem, 2012). Trust among the key stakeholders in PMMS can be improved according to activities in the Establish phase and A21, A31. The trust between the leadership, schools, and external

consultants will make the people feel that they are able to make the transition well.

7.4 Summary

This chapter has presented a discussion of the research results. Whilst giving insights into the significance of findings of this study, the chapter has discussed the advantages of the PIE framework that help solve the challenges in the existing model of PMMS. The discussion pointed out that activities in the Establish stage are essential for improving understanding, engagement, and communication between all the people involved that might also help solve potential resistance to change among staff. The discussion also highlighted that the Evaluate and Improve stages are needed for the improvement of PMMS. This chapter extended the discussion further to explain control factors in PMMS. Furthermore, barriers for the implementation of the PIE framework in practice were discussed and solutions for these barriers were proposed accordingly. Based on that, recommendations for the MoE and schools will be proposed in next chapter.

Chapter 8

Conclusion and Recommendations

8.1 Introduction

This chapter presents conclusions and recommendations drawn from the findings of this research. The first section describes the fulfilment of the aim and objectives by summarising the conclusions from this research. Subsequently, the conclusions drawn from the research are presented and the contributions and limitations are discussed. The chapter also looks at the theoretical and practical implications of the study, including its relevance for the Ministry of Education, schools, and the industry. The last section of the chapter covers the recommendations for further research on asset management in the school context and on facilitating collaboration in managing existing buildings and infrastructure.

8.2 Fulfilment of research objectives

This research study aims to develop a framework for an effective property and maintenance management for state schools in NZ. Four objectives were formulated to achieve the aim. The subsequent sections describe the achievement of objectives in the process and summarise the associated conclusions.

- Objective 1: To review theoretical concepts and previous work on property and maintenance management for schools in the context of asset management.

- Objective 2: To investigate the practice in school property and maintenance management in NZ including processes, roles, responsibilities, and challenges.
- Objective 3: To evaluate maturity level of the responsibilities and determine the most needed improvement areas in PMMS.
- Objective 4: To establish and validate a framework assisting stakeholders of state schools in NZ to manage their property maintenance effectively.

The specific tasks of this research and the key findings are summarised below with respect to the original research objectives:

8.2.1 Objective 1

The literature review on property management and maintenance management in the context of asset management presented in Chapter 2 revealed that managing existing buildings and infrastructure is critical to maximise the value of money invested. An overview of asset management practises determined the key subjects of asset management, including the scope of asset management with its activities, and the interrelationships between activities. The main finding from this review was that there are many requirements and standards for asset management but no guidance on how to implement them, meaning that organisations need to determine the best way to achieve the standards themselves. Some of the asset management frameworks proposed in the literature were reviewed in order to identify the prevalent control factors, types of work, and processes in asset management. The literature review also revealed that the maturity model concept helps organisation assess their current maturity levels and propose areas where they need to develop to increase their maturity levels. Many maturity assessment models were introduced in the asset management field to help asset owners improve their asset management performance.

The literature on asset management in schools was reviewed and it realised that the theory of asset management in schools focuses on technical issues and facility management. There is a lack of research on how the asset management systems work, what the relationships of people involved are and how they collaborate to achieve the defined long-term strategy for the asset management in schools. The need to identify current maturity levels of asset management in

schools and relationships of the key stakeholders was justified based on the lack of insight from previous research in this field.

8.2.2 Objective 2

Using a mixed methods approach, current practice and challenges in the PMMS were identified from the findings of the preliminary study, interviews data and questionnaire survey. Current roles and responsibilities of people involved in PMMS were investigated. The aim and goals of PMMS were achieved by combining the abilities of the Ministry property board (PO), Ministry advisors (PA), external consultants (PP and PM), and school boards (SC). Current activities and processes were also identified, including planning and implementation process. Findings revealed several challenges in the PMMS. Those are summarised as: lack of resources (funding, human resource, information), and incomplete processes (lack of evaluation and improvement).

The control factors for collaboration in the PMMS also were identified from the findings. Those are: top management leadership, competence, and technology. Achievement of goals in PMMS requires the collaboration between stakeholders on both strategic (development of long-term plans) and operational levels (implementation of approved projects). Since different parties are involved in developing the plan and implementing the projects, the Ministry should invest on the effective reporting, communication, and information technology systems to help maintain a high level of collaboration at both levels.

8.2.3 Objective 3

The third objective was to identify the maturity level of activities in PMMS, therefore, improvement actions needed are recommended. The findings from the literature review can be explained using different maturity models focusing on organisations' capability levels to perform, control, and improve their performance in selected process areas.

In PMMS, the process areas were categorised into responsibilities of the key stakeholders: PO, PA, PP, PM, and SC. Indicators of the measurement model were identified based on the activities in PMMS. A maturity level scale with Six levels were developed as: Level 0 - Innocent, Level 1 - Awareness, Level 2 - Developing, Level 3- Applying, Level 4- Optimising, Level 5 - Excellence.

Understanding, goals, and resources for each activity were identified as measures for the maturity scale.

The maturity scores revealed that there is no indicator which has a maturity score greater than Level 4, which means actions should be implemented for improvement. There are ten indicators which have maturity scores between Level 3 and Level 4. These indicators were applied in practice but have not yet achieved optimal standard. Five indicators were belong to the PO's responsibilities (PO5 - training programme, PO6 - performance evaluation, PO8 - reporting system, PO9 - reviewing, PO10 - improvement); three indicators were responsibilities of the PA (PA3 - supporting schools with 5YA, PA6 - sharing lessons, PA7 - helping schools improve their maintenance outcomes); one indicator was the schools' responsibilities (SC9 - collecting and sharing lessons); and one indicator was the property planner's job (PP4 - estimating required fund).

The structural and measurement models of maturity level also help examine the relationships among the key stakeholders in PMMS. The path coefficient values show that PP has the strongest impact on SC, while PM has the strongest effect on PP, and PA has the strongest influence on PM. It is proven that PO has a significant effect on others as top management of PMMS. The findings also reveal that in the model, there are direct, indirect, and mediating relationships among the key stakeholders and the different stakeholders influence each other, which provides further evidence for the suggestion that the relationships between stakeholders are crucial for the success of PMMS. The interrelationships should be considered when proposing the most needed areas for improvement.

The findings also identify how to improve PMMS. These most needed improvement areas were pinpointed by considering the maturity level scores alongside the relationships among the stakeholders. Since PO had influences on PA, PM, and SC, improvement of indicators associated with PO enable improvements for PA, PM, and SC. Indicators which have mean scores below Level 3 of PO are suggested to be high priority for improvement. Moderate priority for improvement is suggested for indicators with mean scores below level 3 of PA, PP, PM, and SC and indicators with mean score between level 3 and level 4 of PO. Low priority for improvement is recommended for indicators with mean scores between level 3 and level 4. These indicators are listed in detail in Table 8.1. According to the list, the activities for evaluation, information management, lesson analysis, engagement,

and training have a high priority for improvement of PMMS. Of moderated priority for improvement are communication, creating and understanding a shared vision, and funding models for PMMS.

Table 8.1: High and moderate priority areas for improvement

Code	**Element**	**Priority**
PO5	Providing training programs for people involved in PMMS	High
PO9	Reviewing the current system against the long-term strategy	High
PO10	Enhancing improvement actions for better delivery of PMMS	High
PO6	Establishing a performance evaluation framework for PMMS	High
PO8	Establishing a reporting system for collecting required information	High
PA6	Sharing knowledge and lessons to help schools resolve property issues	Moderate
PA7	Helping schools improve their property maintenance outcomes	Moderate
SC9	Collecting and sharing lessons for improvement of PMMS	Moderate
PP4	Estimate the required funds for 10YPP plan	Moderate
PA3	Supporting schools to complete their property plans	Moderate
PO3	Providing communication protocols for people involved in the PMMS	Moderate
PO7	Calculating and paying funding for PMMS	Moderate
PO4	Defining roles and responsibilities of all people involved in PMMS	Moderate
PO1	Developing long-term strategies for PMMS	Moderate
PO2	Providing policies for delivery of PMMS	Moderate

8.2.4 Objective 4

The fourth objective was to develop and validate the PIE framework. The key findings emerging from the research were embedded into the PMMS. The Plan-Do-Check-Act cycle was used to develop the E-PIE-I (Establish-Plan-Implement-Evaluate-Improve) cycle, which includes one more process. The added stage (Establish) aims at highlighting the different roles of the key stakeholders in

preparation for the PDCA cycle, thereby helping people involved clearly recognise their roles and responsibilities. Establish also offers school boards to determine if they are able to manage their maintenance management or if they are struggle to maintain their property, they can to move to a centrally managed model. Evaluate and Improve are designed to be completed at anytime in PMMS that help collect feedback, share lessons and make improvement. Each stage consists of several activities and the activities are visually represented by boxes and arrows using IDEF0 modelling language. Input, output, control, and mechanism are mapped for each activity providing a detailed and clear process for the users. All high priority improvement actions are addressed in the PIE framework.

The framework was validated through online interviews with school managers. The school managers provided positive feedback on the clarity and each component in the PMMS framework. All interviewees would like to adopt the PMMS framework in their work. Some recommendations were made by the interviewees to further improve the PIE framework and promote its nation wide adoption. The respondents agreed that evaluation and improvement could be implemented as soon as possible in school property management, and all stakeholders should be on the same page to facilitate the collaboration. The validation results indicated that the PIE framework could be used in practice to improve PMMS.

8.3 Research contributions

There are several key contributions made by this research, which have not been found in previous research studies. This section outlines the key contributions from this study to the existing body of knowledge.

8.3.1 Contribution to literature

The findings of this research contribute to the literature on property management, asset management, maintenance management, and stakeholder relationships in managing existing buildings and infrastructure. The findings of this research have contributed to the theories of relationships of stakeholders engaged in maintenance management. The results revealed that the stakeholders have effects on each other, and the top management plays an important role in PMMS. Relationships among the control factors enabled the development of a more holistic theory of property and maintenance management.

This study also brought a new understanding of applying ISO 55000 series, Plan-Do-Check-Act cycle and Integrated Function Modelling language (IDEF0) to develop a framework for building asset management. Furthermore, this research used for the first time a maturity assessment scale to identify the current maturity level of the responsibilities in PMMS. The findings also presented relationships among the stakeholders that could impact the maturity level of PMMS. Additionally, the research proposed a set of high priority improvement actions for property and maintenance management improvement. The findings of this research thus can help improve the current state of property and maintenance management in school buildings while facilitating collaboration among the key stakeholders.

This research also built on existing literature in mixed methods research in construction field. The findings from qualitative and quantitative data analysis together prove the strength of using mixed methods approach in identifying and solving the research problems.

8.3.2 Contribution to industry

At an applied level, previously, no clear evidence has been discovered regarding the challenges and issues in managing school buildings, especially challenges due to the multi-layered relationships in the school context. This research identified key challenges in the property and maintenance management in New Zealand's state schools and then develop the PIE framework to overcome these challenges.

Overall, this research has developed a new management framework for building properties. The research findings were brought together to develop PIE framework, which provides guidelines for stakeholders to follow from the Establish to the Improvement stages. The PIE framework provides diagrams with detailed activities, to help stakeholders visualise where they are, who they collaborate with, what are needed inputs, what are expected outputs, and what controls the activity. The framework can be used as a guideline for the stakeholders performing their responsibilities in PMMS. Additionally, the framework mapped roles and responsibilities of the key stakeholders offering insights into the involvement of the stakeholders across all stages in PMMS. The PIE framework can be used as a guideline to help people involved in PMMS easily understanding the whole process with detailed activities.

The current level of PMMS was investigated and details of the most needed

improvement elements were identified. In NZ, state schools and the MoE can use the PIE framework and the maturity assessment model to review the current level of PMMS and implement actions needed for improvement.

This framework also provides more support for schools struggling to maintain their property due to the lack of specialist in their schools or due to their isolated location. A centrally managed model can be established to help these schools in managing their property maintenance, and at the same time, reduce the management burden on the school boards and also ensure that school property are well maintained and retaining value of government investment in school buildings.

The assessment model and PIE framework could be adapted to suit other types of buildings, or school buildings in other countries, considering the hierarchical of organisational structure in property and maintenance management.

8.4 Research limitations

Firstly, because the data collection is based largely on schools in New Zealand, applications of the proposed model will be limited to a New Zealand context. Therefore, the research findings may not be able to be generalised. However, the knowledge can be transferred to other research such as using the same methodology to build models for other types of buildings inside New Zealand or for school buildings in other countries.

Secondly, from the beginning of this research, the sample population represented school managers across NZ. However, due to difficulties in reaching respondents for face-to-face interviews, time and resources constraints in this research, the selection of participants for the interviews was limited. However, the sample size is satisfactory for data analysis. This research also did not explore other stakeholders' views in PMMS such as external consultant, staff and students. It is recommended that their influences should be weighted in further research.

Thirdly, the PIE framework has been validated by school managers, so it is likely that it would be introduced and validated by other stakeholders, including the Ministry advisors, property planners, and project managers. The original research plan included a focus group workshop with relevant stakeholders, however, due to the COVID-19 pandemic, only online interviews could be conducted. There is a lack of validation for the PIE framework of other stakeholders in PMMS. Fortunately, in the interviews, the framework received good comments

and feedback from the school managers, who play a critical role in PMMS. That the PIE framework was validated indicates a potential for the PIE framework to be implemented in practice. Additionally, due to limited time, the PIE framework was not implemented in an actual school during the validation process to identify outcomes in real life scenarios. Future work has been suggested to overcome the limitations of this study.

8.5 Recommendations

Considering the findings and conclusions of this research several recommendations can be made to the Ministry of Education, external consultants and school managers to improve property and maintenance management in schools.

8.5.1 The Ministry of Education

This study clearly emphasised the need for MoE reviewing their policies and guidelines in managing the school asset portfolio such as funding models, training programmes, feedback collection, information management and continuous improvement. As discussed in this research, there is a need to provide a long-term strategy to improve capabilities of people involved and increase a shared vision among them. The challenges can be solved by several proposed improvement actions which related to the leadership and management of the Ministry of Education. In all cases, it is important that top-level managers believe that the improvement actions are necessary and act accordingly. The Ministry of Education should establish policies, procedures and processes that increase the stakeholders' motivation towards improving PMMS and facilitating collaboration. Therefore, it is important that MoE introduces the PIE framework to the key stakeholders and issues appropriate policies to enable implementation of PIE framework in practice.

First and foremost, the Ministry of Education should improve collaboration of people involved in PMMS by providing a standardised communication protocol including who, when and how to contact. The guideline should also address that when the information need to be collected and how to access to the recorded information. The PIE framework suggests that MoE should establish a knowledge-based system to provide a data set of problems across all schools in NZ and the solutions for the problems accordingly, which would give external

consultants an overview of the current circumstance of PMMS and help them see whether their abilities fit the job or not. Such a centralised system can help the Ministry figure out what schools need the most support and where money should be spent on and quickly respond to the changes needed to achieve their long-term strategy. Access to the system also helps SC compare their building's condition with other local schools and find a shared resource for solutions. The information system not only enables collaboration at a school level but also can start a collaborative working environment for schools at a regional level. Moreover, knowledge in the operational phase can be transferred to new building projects, which helps the project team produce long-term benefit decisions. The valuable knowledge in PMMS would help the Ministry of Education deliver new buildings and develop additional capacity in a cost-effective manner and then utilise the constructed assets effectively and efficiently. To establish the knowledge-based system, the Ministry of Education need to promote feedback collection and information management by implementing activities in Evaluate and Improve stage. These activities in Evaluate and Improve stage serve to generate lessons to improve the effectiveness of the management (refer section 7.3.1.3). This study also strongly recommend MoE promoting an effective feedback collection and information management system. It should not only be formed at a project level or a school level, it should be also implemented at regional or portfolio level. This system will help MoE recognise schools with the greatest needs and prioritise policies and funding models accordingly.

This study pointed out that the participants were not satisfied with the current training programmes provided by the Ministry of Education. Hence, this research recommends the development of an online training system and knowledge sharing platform that allows for the stakeholders to continuous educate themselves on the ins and outs of PMMS. Have a place where knowledge and experience are shared may not only ease the frequent turnover of the staff but also improve the transparency of the process. Therefore, at Establish stage, the Ministry should determine the necessary competence of staff and job requirements to provide appropriate education and training to acquire the necessary competence. As mentioned in section 7.3.1.2, the Ministry of Education should introduce an online-based training system due to the different locations of the stakeholders that could help the Ministry to update the information quickly and participants could review the sessions at any time.

Due to the inconsistent maintenance practices, while some schools (secondary schools) have sufficient resources and capability to manage their property, small and remote schools are struggling with the management. MoE should recognise schools with the great needs and can develop a centrally managed model to help reduce the burden on school boards (refer section 7.3.2)

8.5.2 School managers

This study recommends that school managers adopt steps outlined in the PIE framework to ensure internal improvement in PMMS. School managers who are responsible for property matters should clearly understand MoE's requirements for PMMS and align these requirements with the long-term development plan of their schools. School managers are expected to closely engage with Ministry advisors and external consultants to complete the property plans.

At school level, it is important that schools record maintenance information, collect lessons, report to the MoE, and review their current system. Maintenance information is important to make decisions for future renewal alternatives such as renovation or refurbishment. Therefore, school managers should pay attention on the information management of all maintenance work and provide the information to other stakeholders if required.

While waiting for a centrally managed model introduced by MoE, secondary schools and large schools should support small schools and remote schools in developing a model of resource-sharing. Property managers, who work for advantaged schools, can work for smaller or remote schools in neighbouring areas. They can do part-time jobs such as one day per week at small and remote schools to advise and assist principals in managing their maintenance work. Schools can also share information about contractors or solutions for an effective maintenance management. Savings in cost and effort will follow if the sharing-resource model works, especially for schools in rural areas.

8.5.3 External consultants

This study recommends that external consultants play an important role in PMMS and they should work closely with school managers and Ministry advisors to achieve objectives of PMMS. Property planners should clearly understand the

requirements from MoE, as well as the schools' context to develop 10YPP. Finding from the maturity level scores suggest that the estimation of the required fund for 10YPP (PP4) needs to be improved. While the PIE framework allows information at every stage to be collected (refer section 7.3.1.3), therefore, a database of maintenance cost can be established. Based on the database, a cost plan for property and maintenance management can be developed (refer section 7.3.3). The property planners and other stakeholders can use the cost plan as a reference when developing 10YPP. It is also suggested that property planners should collaborate with school managers to address all property matters and advise the schools to select the most appropriate maintenance management model (section 7.3.2).

Although there is no priority for improvement for project managers (PM), it is still suggested communication and collaboration of PM and other stakeholders is important to the performance of PMMS. The path models reveal that PP has the strongest effects on PP, while PP has the strongest impacts on SC, and PA has the strongest influence on PM. In the PIE framework, while PM has the main role of delivering approved projects, it is important that PM handover the needed information for schools to maintain their property effectively (A34, A35, at Implement stage). Project managers also are expected to work closely with Ministry advisors to evaluate performance of the projects and report feedback and reflections for improvement (Evaluate and Improve stage). The information recorded and reported by project managers will help property planners, Ministry advisors and school managers to prepare for the cycle of 5YA and 10YPP.

8.6 Future work

There are opportunities to extend the outcomes of this research through further investigations. The data collection was subjected to few limitations as discussed in Section 8.4. Thus, it is necessary to consider the participation of other stakeholders. It would be useful to validate these research findings by external consultants. The comments and feedback from MoE staff and external consultants might help improve the PIE framework. It could be argued that the findings may have been different if another design method was used. Hence, it is recommended that future studies consider different research designs to validate the research findings.

In order to facilitate a wider adoption of the PIE framework, a number of future studies can be recommended. The PIE framework did not include a user guide, and it is suggested a further study develops a user guide for all stakeholders involved. Additionally, it would be useful to develop template documents and tools to use along with the framework to more easily implement the guidelines proposed by the PIE. Further research could focus on a detailed implementation strategy for the proposed PIE.

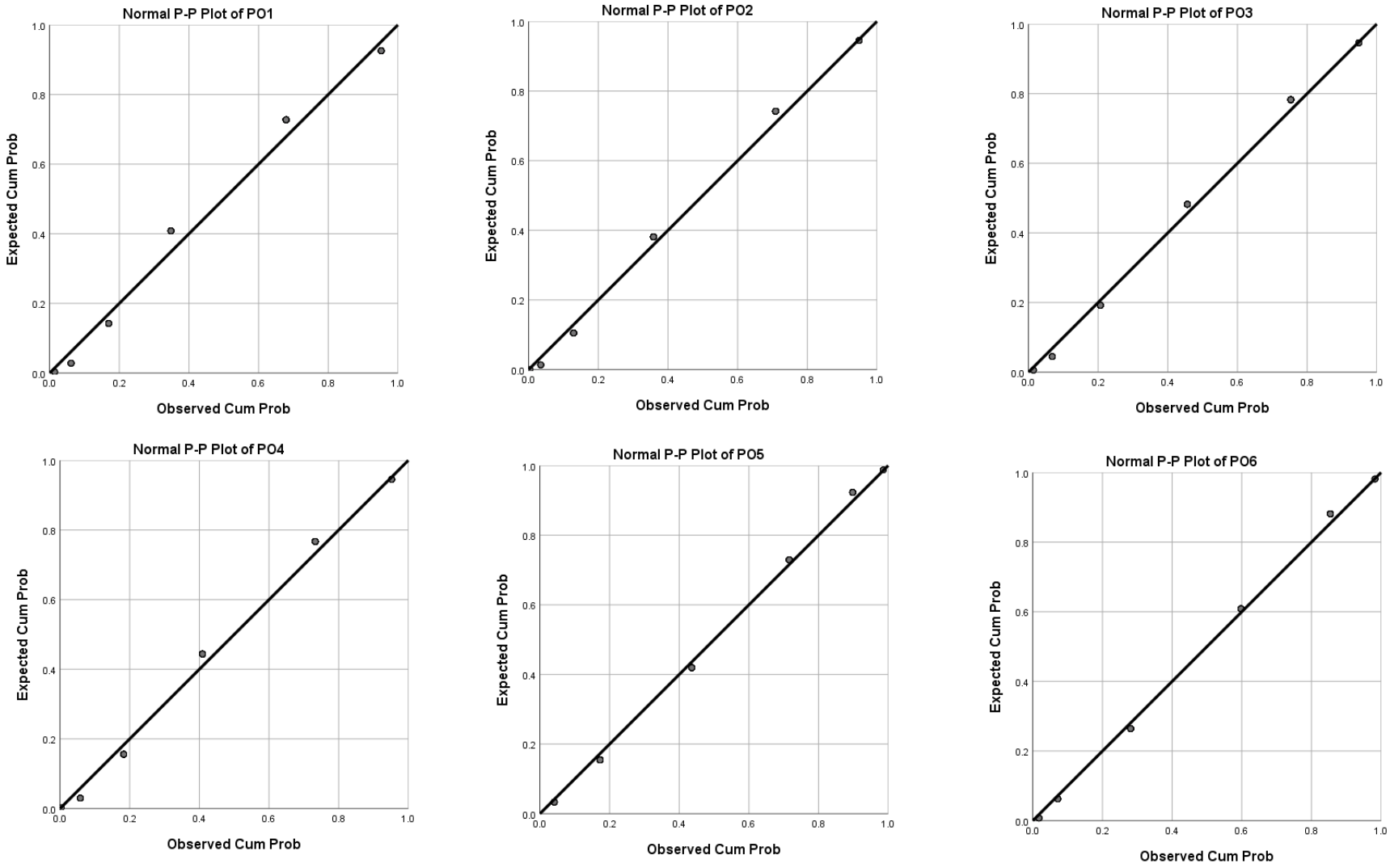
As discussed, the development of a cost plan for short- and long-term budgeting in PMMS could be considered in future research. Pattern expenditures, necessary work, and frequencies of work should be recommended using the database of the Ministry of Education. The development of a knowledge management system for PMMS is also recommended for future work. Further work also is recommended to conduct some case studies in several schools for the implementation of PIE framework.

It is suggested that future work should conduct case studies of implementing PIE framework in several schools for managing their 5YA projects. There are some criteria should be considered while selecting the case studies such as the type of schools (primary or secondary), the location of schools and the size of schools (number of student enrolled). Findings from the case studies can provide lesson learn for other schools with similar context.

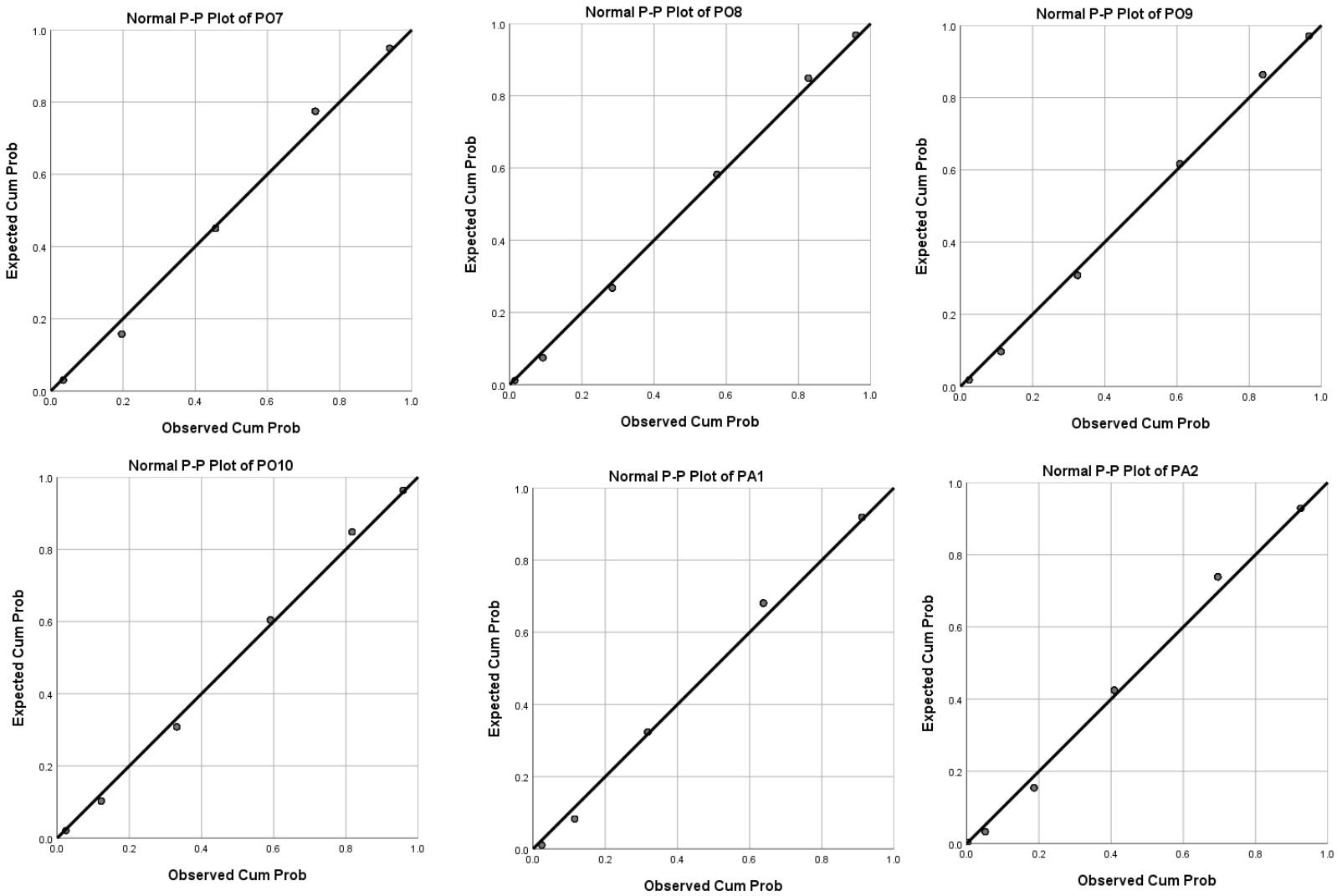
The PIE framework is designed for the school context in NZ. It would be appropriate to use the research methodology to develop a similar framework for other types of buildings in NZ or for schools in other countries. The maturity assessment model can be used in any field for improvement. In that sense, the PIE framework could be customised to assess the maturity level of managing existing buildings towards improvement.

Appendix A

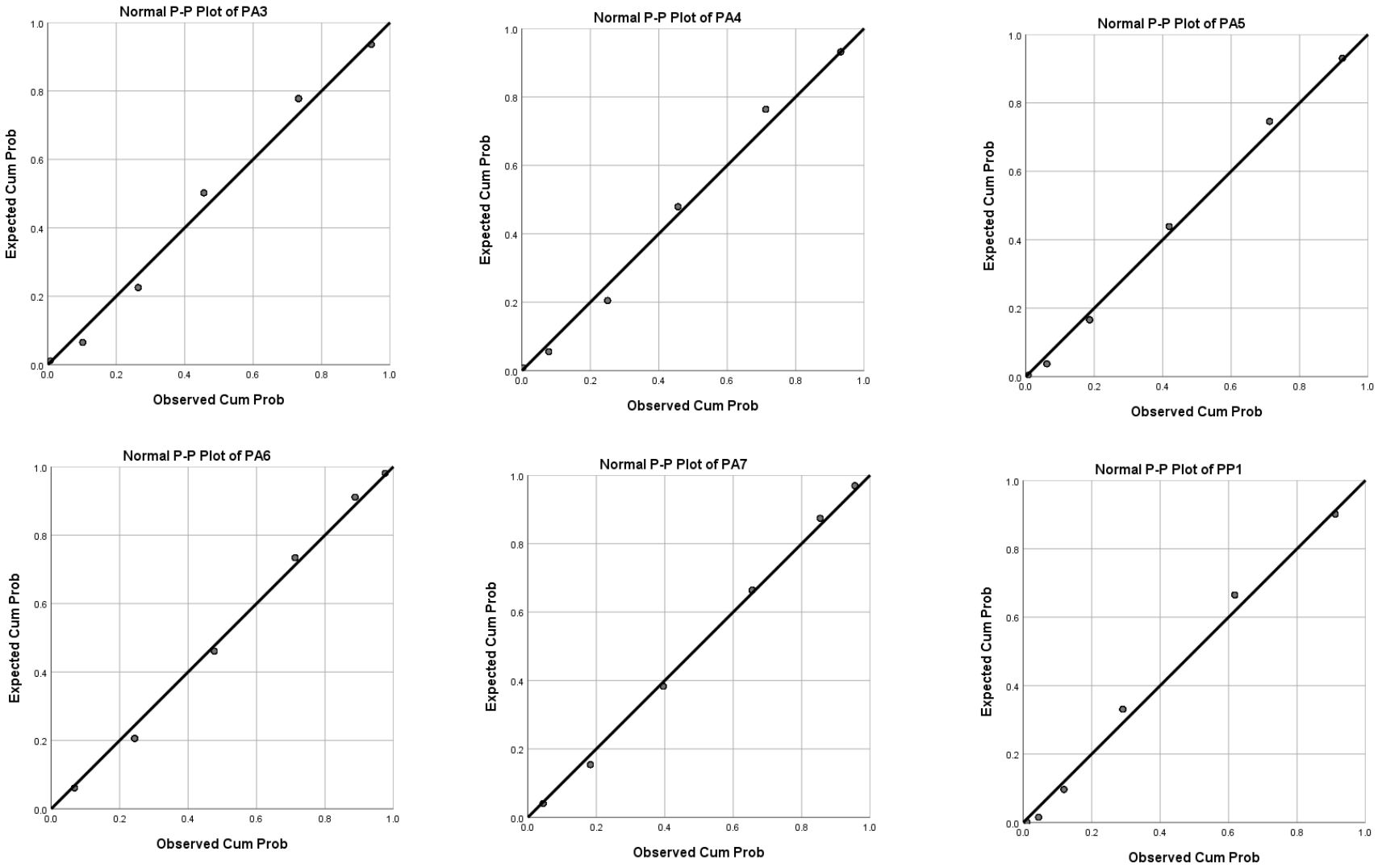
Normality of the Variables



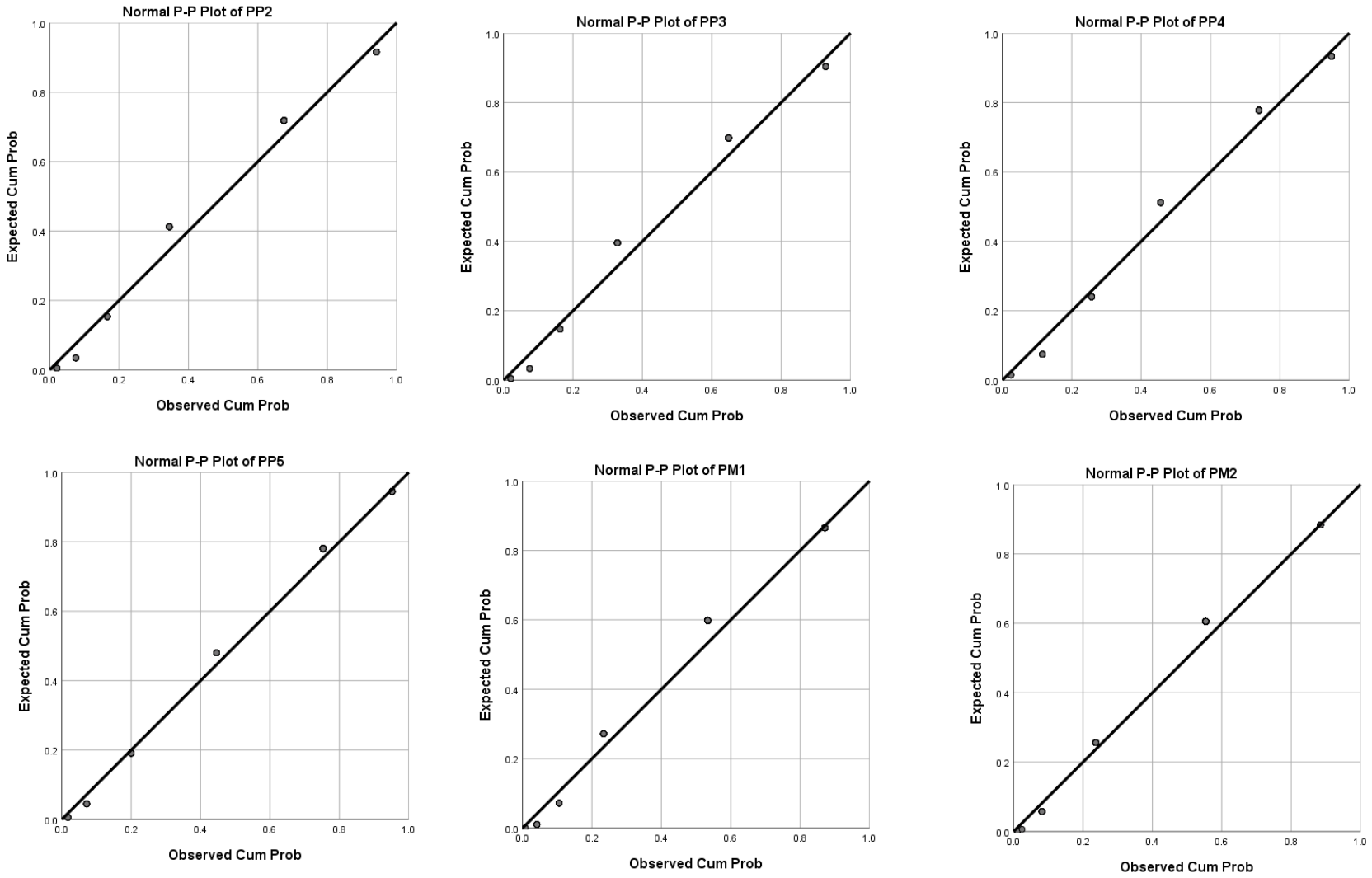
P-P Plot of Variables (PO1,2,3,4,5,6)



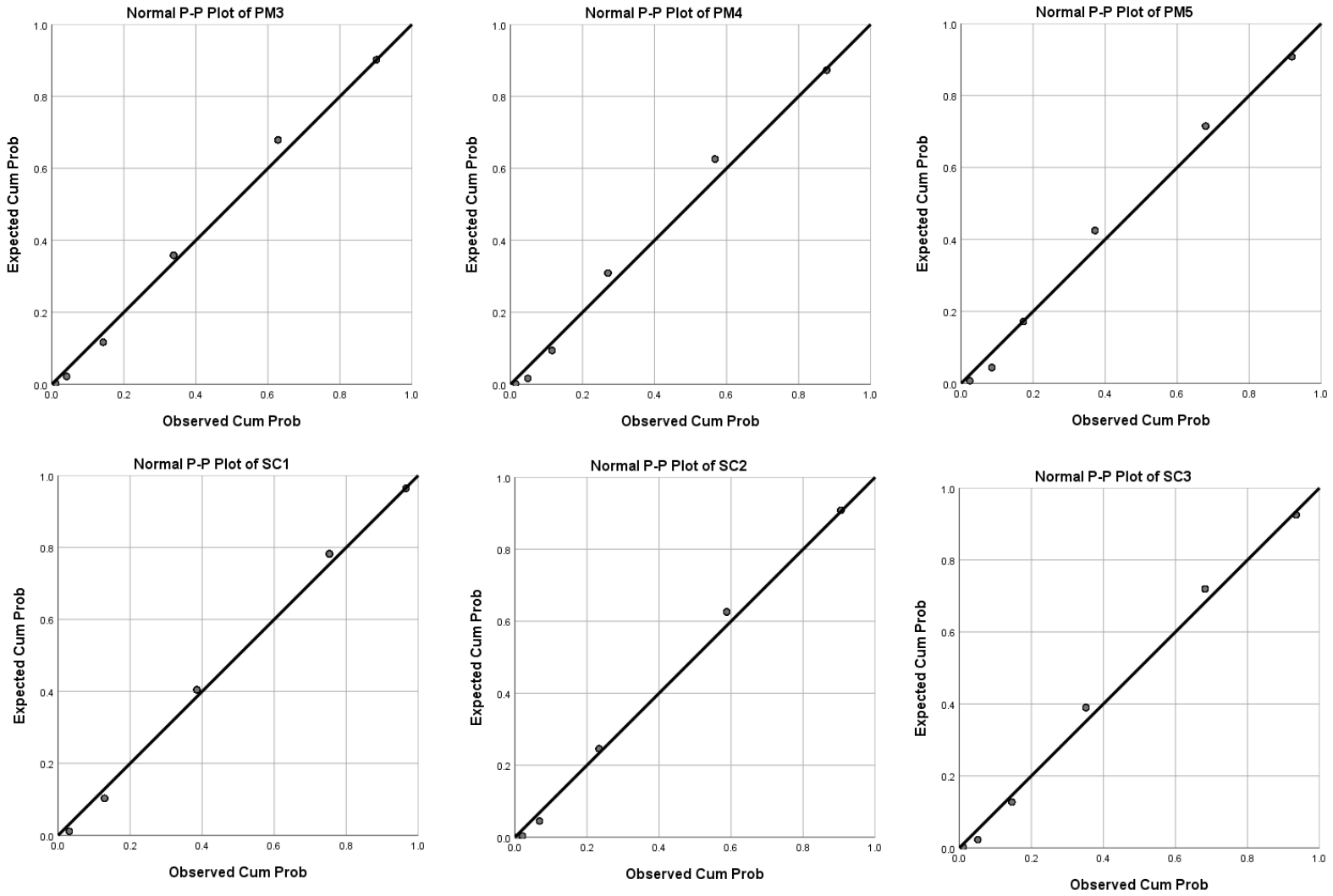
P-P Plot of Variables (PO7,8,9,10; PA1,2)



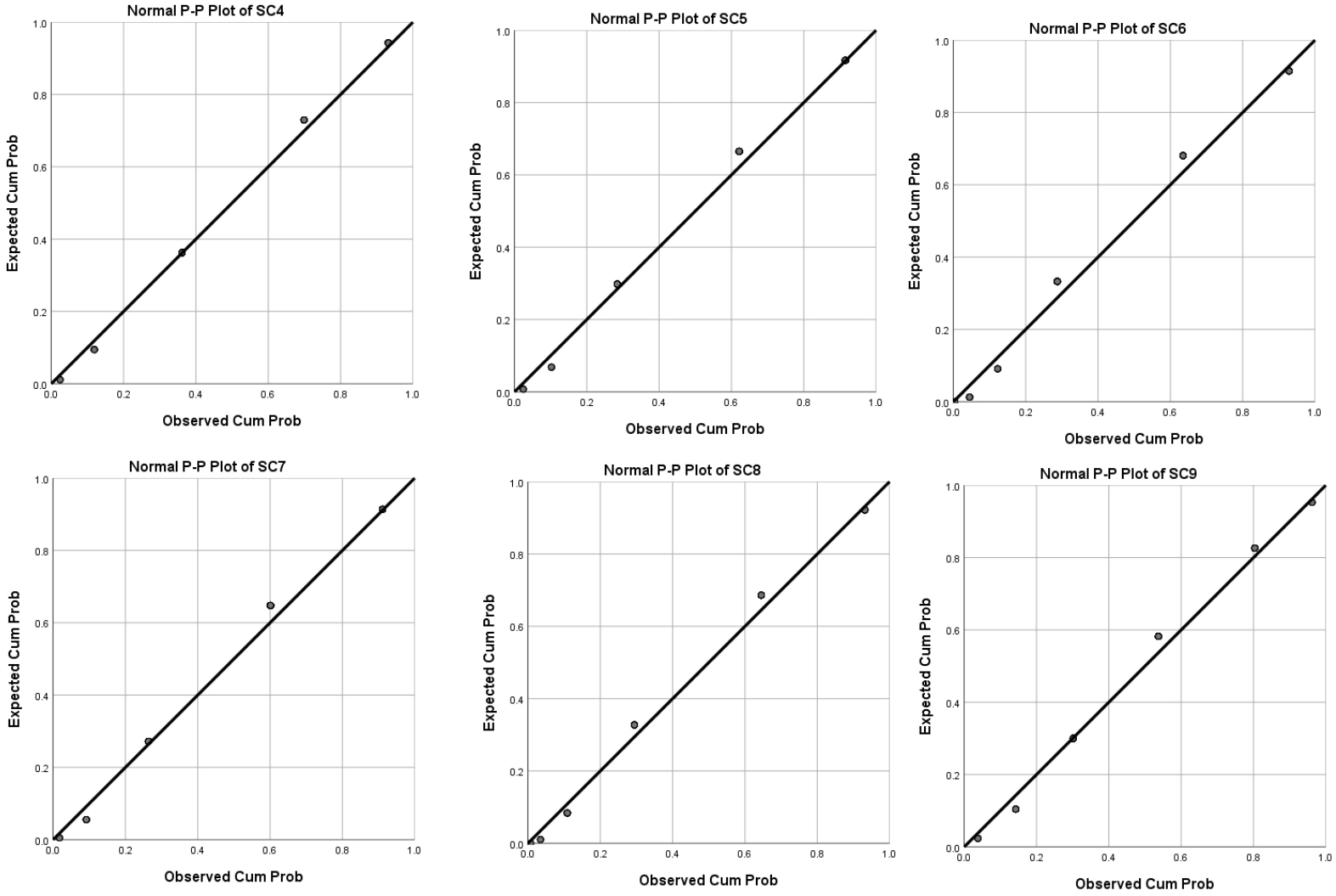
P-P Plot of Variables (PA3,4,5,6,7; PP1)



P-P Plot of Variables (PP2,3,4,5; PM1,2)



P-P Plot of Variables (PP3,4,5; SC1,2,3)



P-P Plot of Variables (SC4,5,6,7,8,9)

Appendix B

Descriptive Statistics of the Variables

Descriptive Statistic for PO, PA, PP, PM and SC

Descriptive Statistics for PO								
Indicator	Mean	Std.Devi	Frequencies					
			Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
PO1	3.28	1.194	4	10	22	31	**67**	14
			2.7%	6.8%	14.9%	20.9%	45.3%	9.5%
PO2	3.32	1.050	1	8	20	48	**56**	15
			0.7%	5.4%	13.5%	32.4%	37.8%	10.1%
PO3	3.05	1.211	4	12	29	**45**	43	15
			2.7%	8.1%	19.6%	30.4%	29.1%	10.1%
PO4	3.16	1.149	1	15	22	45	**51**	14
			0.7%	10.1%	14.9%	30.4%	34.5%	9.5%
PO5	2.25	1.228	12	27	**51**	32	22	4
			8.1%	18.2%	34.5%	21.6%	14.9%	2.7%
PO6	2.70	1.104	5	11	**51**	43	33	5
			3.4%	7.4%	34.5%	29.1%	22.3%	3.4%
PO7	3.14	1.137	0	10	38	39	**43**	18
			0.0%	6.8%	25.7%	26.4%	29.1%	12.2%
PO8	2.75	1.211	4	19	38	**48**	27	12
			2.7%	12.8%	25.7%	32.4%	18.2%	8.1%
PO9	2.63	1.252	7	19	**44**	40	28	10
			4.7%	12.8%	29.7%	27.0%	18.9%	6.8%
PO10	2.66	1.308	7	22	**40**	37	30	12
			4.7%	14.9%	27.0%	25.0%	20.3%	8.1%

Descriptive Statistics for PA								
Indicator	Mean	Std.Devi	Frequencies					
			Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
PA1	3.49	1.079	0	7	20	40	**55**	26
			0.0%	4.7%	13.5%	27.0%	37.2%	17.6%
PA2	3.23	1.207	1	13	27	39	**46**	22
			0.7%	8.8%	18.2%	26.4%	31.1%	14.9%
PA3	2.99	1.317	2	26	22	35	**47**	16
			1.4%	17.6%	14.9%	23.6%	31.8%	10.8%
PA4	3.07	1.297	1	21	30	31	**45**	20
			0.7%	14.2%	20.3%	20.9%	30.4%	13.5%
PA5	3.19	1.225	2	14	23	**46**	41	22
			1.4%	9.5%	15.5%	31.1%	27.7%	14.9%
PA6	2.14	1.383	20	32	**37**	33	19	7
			13.5%	21.6%	25.0%	22.3%	12.8%	4.7%
PA7	2.41	1.385	13	28	35	**42**	17	13
			8.8%	18.9%	23.6%	28.4%	11.5%	8.8%

Descriptive Statistics for PP								
Indicator	Mean	Std.Devi	Frequencies					
			Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
PP1	3.51	1.158	3	7	15	36	**61**	26
			2.0%	4.7%	10.1%	24.3%	41.2%	17.6%
PP2	3.28	1.250	6	10	17	36	**62**	17
			4.1%	6.8%	11.5%	24.3%	41.9%	11.5%
PP3	3.34	1.275	6	10	16	33	**62**	21
			4.1%	6.8%	10.8%	22.3%	41.9%	14.2%
PP4	2.96	1.360	7	20	22	37	**47**	15
			4.7%	13.5%	14.9%	25.0%	31.8%	10.1%
PP5	3.06	1.213	5	11	27	**46**	45	14
			3.4%	7.4%	18.2%	31.1%	30.4%	9.5%

Descriptive Statistics for PM								
Indicator	Mean	Std.Devi	Frequencies					
			Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
PM1	3.71	1.168	2	8	11	27	**62**	38
			1.4%	5.4%	7.4%	18.2%	41.9%	25.7%
PM2	3.71	1.083	3	1	16	30	**64**	34
			2.0%	0.7%	10.8%	20.3%	43.2%	23.0%
PM3	3.44	1.208	3	6	24	34	**52**	29
			2.0%	4.1%	16.2%	23.0%	35.1%	19.6%
PM4	3.61	1.221	4	6	14	32	**56**	36
			2.7%	4.1%	9.5%	21.6%	37.8%	24.3%
PM5	3.25	1.319	7	11	15	44	**47**	24
			4.7%	7.4%	10.1%	29.7%	31.8%	16.2%

Descriptive Statistics for SC								
Indicator	Mean	Std.Devi	Frequencies					
			Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
SC1	3.24	0.978	0	9	20	**56**	53	10
			0.0%	6.1%	13.5%	37.8%	35.8%	6.8%
SC2	3.68	0.990	1	4	10	39	**66**	28
			0.7%	2.7%	6.8%	26.4%	44.6%	18.9%
SC3	3.32	1.162	3	9	19	42	**56**	19
			2.0%	6.1%	12.8%	28.4%	37.8%	12.8%
SC4	3.36	1.038	0	7	21	**51**	49	20
			0.0%	4.7%	14.2%	34.5%	33.1%	13.5%
SC5	3.55	1.045	0	7	16	38	**62**	25
			0.0%	4.7%	10.8%	25.7%	41.9%	16.9%
SC6	3.48	1.109	1	11	12	37	**66**	21
			0.7%	7.4%	8.1%	25.0%	44.6%	14.2%
SC7	3.61	1.014	0	5	17	34	**66**	26
			0.0%	3.4%	11.5%	23.0%	44.6%	17.6%
SC8	3.48	1.072	2	6	16	39	**65**	20
			1.4%	4.1%	10.8%	26.4%	43.9%	13.5%
SC9	2.72	1.365	11	20	27	**43**	36	11
			7.4%	13.5%	18.2%	29.1%	24.3%	7.4%

Table B1: Stop Criterion in Smart PLS								
	PA1	**PA2**	**PA3**	**PA4**	**PA5**	**PA6**	**PA7**	**PM1**
Iteration 0	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.226
Iteration 1	0.155	0.177	0.166	0.173	0.189	0.169	0.187	0.223
Iteration 2	0.155	0.177	0.166	0.174	0.189	0.168	0.186	0.223
Iteration 3	0.155	0.177	0.166	0.174	0.189	0.168	0.186	0.223
Iteration 4	0.155	0.177	0.166	0.174	0.189	0.168	0.186	0.223
	PM2	**PM3**	**PM4**	**PM5**	**PO1**	**PO10**	**PO2**	**PO3**
Iteration 0	0.226	0.226	0.226	0.226	0.132	0.132	0.132	0.132
Iteration 1	0.226	0.221	0.222	0.239	0.127	0.133	0.127	0.152
Iteration 2	0.226	0.221	0.223	0.240	0.128	0.133	0.127	0.152
Iteration 3	0.226	0.221	0.223	0.240	0.128	0.133	0.127	0.152
Iteration 4	0.226	0.221	0.223	0.240	0.128	0.133	0.127	0.152
	PO4	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PP1**	**PP2**
Iteration 0	0.132	0.132	0.132	0.132	0.132	0.132	0.233	0.233
Iteration 1	0.134	0.117	0.124	0.130	0.131	0.136	0.226	0.223
Iteration 2	0.134	0.117	0.124	0.129	0.131	0.136	0.227	0.222
Iteration 3	0.134	0.117	0.124	0.130	0.131	0.136	0.227	0.222
Iteration 4	0.134	0.117	0.124	0.130	0.131	0.136	0.227	0.222
	PP3	**PP4**	**PP5**	**SC1**	**SC2**	**SC3**	**SC4**	**SC5**
Iteration 0	0.233	0.233	0.233	0.141	0.141	0.141	0.141	0.141
Iteration 1	0.248	0.220	0.248	0.162	0.124	0.120	0.156	0.169
Iteration 2	0.248	0.220	0.248	0.162	0.124	0.120	0.156	0.169
Iteration 3	0.248	0.220	0.248	0.162	0.124	0.120	0.156	0.169
Iteration 4	0.248	0.220	0.248	0.162	0.124	0.120	0.156	0.169
	SC6	**SC7**	**SC8**	**SC9**				
Iteration 0	0.141	0.141	0.141	0.141				
Iteration 1	0.135	0.146	0.142	0.107				
Iteration 2	0.134	0.146	0.142	0.107				
Iteration 3	0.134	0.146	0.142	0.107				
Iteration 4	0.134	0.146	0.142	0.107				

Appendix C

Preliminary Interview Questions and Survey

Preliminary Interview Questions

During the training courses, the researcher had been connected with PA, PP and PM. Two interviews were conducted after the first course to understand the current practice in PMMS. Apart from background questions, main questions in the interview are:

Question 1: How property projects are prioritised and estimated? *(How decisions are made, who involved, what are inputs and outputs, etc)*

Question 2: How key parties in PMMS are working together towards common goals? *Who involved, what are key roles, how the people communicate, etc*

Question 3: What are challenges in current processes? *resource constraints, communication issues*

If there are any other issues which you feel are relevant to this research please feel free to raise them now.

Thank you very much for participating in this study.

Preliminary Survey

A short survey was distributed to 13 participants during the second course aiming at (1) investigating the level of influences of key roles in managing property projects in schools (2) identifying key challenges in managing school property projects, as photo below:

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UNIVERSITY OF NEW ZEALAND

Developing a Framework for Managing School Buildings in New Zealand

I wish to invite you to participate in a survey, aiming at (1) investigating the level of influences of key roles in managing property projects in schools (2) identifying key challenges in managing school property projects.

The questions should take no longer than 15 minutes to respond. You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question; withdraw from the study at any time during the survey;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded

This project has been evaluated by peer review and judged to be low risk through the Massey Human Ethics Committees. The researcher named in this document are responsible for the ethical conduct of this research. *If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher, please contact Dr. Brian Finch, Director – Ethics, telephone 063569099 ext 86015, email: humanethics@massey.ac.nz*

If any queries arise, please contact:

Researcher's Name and Contact Details
An Le
Phd student,
School of Engineering and Advance Technology
Massey University, Auckland
Email: a.lethihoai@massey.ac.nz
Phone: +64 2240

Section A: Background Information

1. **Please indicate your job title**

Project Manager	
Property Planner	
MOE Advisor	
Others (please indicate)	

2. **Please indicate years of experience in the school property projects with the MOE**

Less than 2 years	
2-5 years	
5-10 years	
Over 10 years	

3. **How many schools have you been engaged with?**

Less than 5 schools	
5-10 schools	
10-15 schools	
Over 15 schools	

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Section B: Identifying roles and challenges in managing school property

Note: Based on your experience, how would you **evaluate** each of the factors below on a scale of 1-5? *Please don't mind to select "N/A" if any factor is not applicable to your opinion or your experience.*

1. **Role of key stakeholders in planning property projects.**
   Number 1 represents "very low" and number 5 means "very high"

Code	Factors	1	2	3	4	5	NA
E1	School board						
E2	Property Planner						
E3	Project Manager						
E4	MoE Advisor staff						
	Others (please indicate)						

2. **Roles of key stakeholders in implementing projects.**

Number 1 represents "very low" and number 5 means "very high"

Code	Factors	1	2	3	4	5	NA
M1	School board						
M2	Property Planner						
M3	Project Manager						
M4	MoE Advisor staff						
	Others (please indicate)						

3. **Challenges in planning and implementing property projects**

Number 1 represents "strongly disagree" and number 5 means "strongly agree"

Code	Factors	1	2	3	4	5	NA
C1	Understanding and interests of school board in PMM						
C2	Capability of people involved						
C3	Collaboration of people involved in 10YPP process						
C4	Collaboration of people involved in managing 5YA projects						
C5	Information transparency between the stakeholders						
C6	Budget allocation						
C7	Historic data of previous projects						
C8	Monitoring process to ensure that the strategic goals are achieved						
	Others (please indicate)						

Thank you for your kind help in completing these questions above.

Sent: Thursday, 5 October 2017 2:38 PM
To: Le Thi Hoai, An
Subject: RE: 2017 Condition Assessment Training for 10YPP Consultants
Attachments: Ten Year Property Planning programme.docx

Importance: High

Hi An,

Please confirm your attendance at the upcoming 10YPP training.

The details:
What: 10YPP Training
When:10/10/2017 at 8:30am
Where: Christchurch Ministry of Education Office - Te Urutī,
48 Hereford Street,
West End,
Christchurch 8013.

What I need from you:
- Confirmation of attendance
- Any dietary requirements
- To get familiarised with the following pages on the Ministry's website:
  - Ten Year Property Planning (10YPP)
  - Five Year Agreement Funding (5YA)
  - Board funding for property projects
  - Property Maintenance Grant
  - Funding

What I have supplied(attached):
- A copy of the itinerary

I look forward to your response.

Appendix D

Interview Questions for Qualitative Data

The aim of the interview is to discover the current practice and challenges which schools experience in managing their properties.

Interview Questions

Part 1 - to collect participants' background information

Q1: What is your your job title and your role in managing school property?

Q2: How many years you have been working with the role?

Q3: How many students enrolled in your school this year (roughly number)

Q4: Please share some information of your school buildings and infrastructure characteristics (form below)

Part 2- To understand current property and maintenance management practice

The main questions are below with keywords of sub-questions.

Q1: What are key roles in managing school properties? *(roles, responsibilities, activities, etc)*

Q2: Based on your experience, how property plans be developed at your school? *(identify/prioritise property projects, maintenance tasks, condition assessment process, budget estimation, etc)*

Q3: Based on your experience, how your school implements the property plans? *(outsourcing process, procurement process, project monitoring, etc)*

Q3: Based on your experience, how property projects and maintenance tasks are evaluated? *(criteria, evaluation process, reporting, etc)*

Q4: Based on your experience, how property information are captured, updated and stored at your school and at MoE? *(information collection, data analysis, lesson learnt, etc)*

Q5: Have your school experienced any issues or challenges relating to managing school properties? *(budget, workmanship, communication, etc)*

Q6: Do you think what are control factors for effectively managing school properties? *(skills, communication, information, etc)*

Part 3 - Further discussion and site visit

If there are any other issues which you feel are relevant to this research please feel free to raise them now.

After each interview, the researcher had a visit around the school site to gain an overview of buildings and infrastructure condition in the schools.

SCHOOL VISIT FORM

Function areas: Yes or No

Space	**Y/N**
Administration area Administration; staff room; staff offices; meeting; counseling; bookstore; sick bay; caretaker; grounds storage.	
Classroom and learning areas	
Library area	
Gymnasium area	
Kitchen/food preparation areas	
Swimming pool	
Toilet areas	
Playground	
Laboratory area	
Technology block	
Multipurpose area	
Non-MoE space	
Resource area	
Car park	
Other (please specify)	

Building Characteristics: circle or write down

Number of storey	
External works area (m2) roughly	
The gross internal floor area of the building (m2)	
Structural type	timber-frame, concrete frame
Roof structure	metal tiles, aluminum sheets, timber roof
External wall type	wood-frame, curtain walling
External windows and doors	double-glazed, aluminum/ wood-frame
Internal doors	Flush hardwood, PVC, sliding, folding
Internal wall type	stub partitions, plasterboard, PVC sheeting
Flooring	Carpet, vinyl sheet, wood, ceramic tiles, stone
Ceilings	Timber-framed plasterboard, suspended ceiling, acoustic plasterboard
Heating system	Heat pump, gas boiler, underfloor heating, heater
Air-conditioning and Ventilation	Y/N
Communication and security system	Y/N
Fire protection	Y/N
Water installation (hot and cold water)	Y/N
External drainage	Y/N
Gate and fencing	Y/N
Tree and plants, soft landscaping	Y/N
Others (specify)	

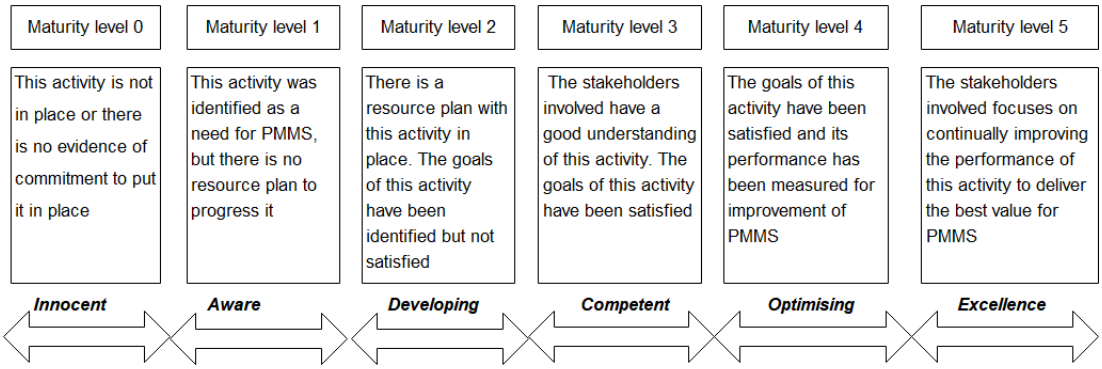
Appendix E

Questionnaire Survey

This survey aims to evaluate maturity levels of different activities in school property management. The questionnaire survey starts with an introduction of the research, the consent form and explanation of maturity level scale used in this research.

Maturity level scale:

Based on YOUR EXPERIENCE, please evaluate the current level for the following activities regarding Ministry Property Board/Ministry advisor/property planner/project manager and school board role in managing school properties, on a scale of maturity level from 0 to 5 (NA: if not applicable).



Session A: Participant Background Information

1. **Your primary role in school property management**
   1- Principal/Deputy Principal
   2- Property manager
   3- School Board member
   4- School Executive Officer
   5- Business manager
   6- Others (please indicate) .....

2. **Type of your school**
   1. Primary
   2. Secondary
   3. Intermediate
   4. Others (please indicate) .....

3. **Your school's location**
   1. Main urban area
   2. Minor urban area
   3. Secondary urban area
   4. Rural area
   5. Other (please indicate) .....

4. **The average number of students enrolled each year in your school**
   1. <100
   2. 101-200
   3. 201 to 500
   4. 501 to1000
   5. 1001 to 2000
   6. >2000

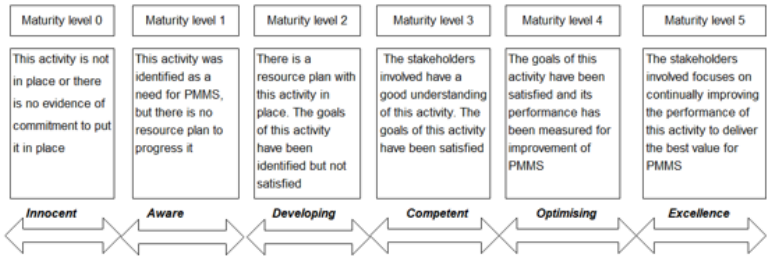
5. **How many years have you experienced in the school property management domain?**
   1. < 2 years
   2. 2 to 5 years
   3. 5 to 10 years
   4. greater than 10 years

Background questions for Property Advisor (plus question 5 above)

1. **How many schools have you been working with?**
   1. <10
   2. 11-30
   3. 31-50
   4. >50

Session B: Evaluate maturity level of PMMS

Based on **YOUR EXPERIENCE**, please evaluate the current level for the following activities regarding Ministry Property Board/Ministry advisor/property planner/project manager and school boards in managing school properties, on a scale of maturity level from 0 to 5 (NA: if not applicable).



Note: PMMS stands for "Property and Maintenance Management in Schools"

Ministry Property Board

Code	Activity	0	1	2	3	4	5	NA
PO1	Developing long-term strategies for PMMS							
PO2	Providing policies for delivery of PMMS							
PO3	Providing communication protocols for people involved in PMMS							
PO4	Defining roles and responsibilities of all people involved in PMMS							
PO5	Providing training programmes for people involved in PMMS							
PO6	Establishing a performance evaluation system for PMMS							
PO7	Calculating and paying funding for PMMS							
PO8	Establishing a reporting system for collecting required information							
PO9	Reviewing the current PMMS system against the long-term							
PO10	Enhancing improvement actions for better delivery of the PMMS							
	Others (please write in)							

Ministry advisor

Code	Activity	0	1	2	3	4	5	NA
PA1	Understanding their roles and responsibilities in PMMS							
PA2	Co-ordinating completion of 10YPP for schools							
PA3	Supporting schools to complete their property plans							
PA4	Connecting schools to MoE							
PA5	Monitoring the school property projects							
PA6	Sharing knowledge and lessons to help schools resolve their property issues							
PA7	Helping schools improve their property maintenance outcomes							
	Others (please write in), NA if not applicable							

School board

Code	Activity	0	1	2	3	4	5	NA
SC1	Understanding their roles and responsibilities in PMMS							
SC2	Understanding staff and students' need for school buildings and infrastructure							
SC3	Ensuring property projects align with school activities and objectives							
SC4	Ensuring that maintenance management at the school complies with legal and MoE requirements							
SC5	Engaging with PP and PA to prepare 10YPP							
SC6	Ensuring day-to-day maintenance of school property							
SC7	Ensuring school follows the approved property plan							
SC8	Recording and updating information for PMMS							
SC9	Collecting and sharing lessons for improvement of PMMS							
	Other (please write in)							

Property planner

Code	Activity	0	1	2	3	4	5	NA
PP1	Understanding their roles and responsibilities in PMMS							
PP2	Conducting condition assessment							
PP3	Preparing 10YPP							
PP4	Estimating the required funds for the plan							
PP5	Ensuring asset condition information is updated in the Ministry's property condition database and shared with schools							
	Others (please write in)							

Project manager

Code	Activity	0	1	2	3	4	5	NA
PM1	Understanding their roles and responsibilities in PMMS							
PM2	Selecting appropriate contractors for the approved projects							
PM3	Ensuring projects are implemented in an effective and timely manner							
PM4	Helping schools prioritise maintenance tasks for constructed facilities							
PM5	Ensuring required information is updated in the Ministry property database and shared with schools							
	Others (please write in)							

/

Appendix F

Evaluation Form

This framework can be used as a guideline for school managers to manage their property effectively. Therefore, the research highly requires end-users' feedback on the framework. The evaluation consists of two parts as followings:

First part: A short presentation to introduce the proposed framework for Property and Maintenance Management in Schools (PMMS), which is the primary objective of this research.

Second part: To discuss other findings of this research including the maturity level of all elements in the PMMS and relationships among the key stakeholders. The discussion is aim to produce specific and practical recommendations.

Evaluation Questionnaire

Part 1: Background information

- Type of school
- Position
- Number of students enrolled
- Years of experience

Part 2: Framework evaluation questions:

Please evaluate the following statement by circling the appropriate number from 1 to 5 as following:

1 = Strongly disagree; 2 = Disagree; 3 = Neither Agree/Disagree; 4 = Agree; 5 = Strongly Agree

Questions	Answers				
Logic and clarity of the framework:					
1- The structure of the proposed framework is clear.	**1**	**2**	**3**	**4**	**5**
2- The contents presented in the framework are precise.	**1**	**2**	**3**	**4**	**5**
3- It is easy to follow the processes and sub-processes of the framework.	**1**	**2**	**3**	**4**	**5**
Evaluation of the framework's functions					
4- The framework can help property people understand PMMS processes and requirements in certain activities.	**1**	**2**	**3**	**4**	**5**
5- The maturity assessment model can help identify maturity level of PMMS.	**1**	**2**	**3**	**4**	**5**
6- The framework can help improve overall efficiency of PMMS.	**1**	**2**	**3**	**4**	**5**
7- The framework can help identify high priority areas for improvement of PMMS.	**1**	**2**	**3**	**4**	**5**
8- The framework help improve collaboration of the stakeholders in PMMS	**1**	**2**	**3**	**4**	**5**

Part 2: Further evaluation questions

9- What do you consider the main advantages/main improvements of the framework in comparison with the current practice?

10- What do you think are the likely obstacles/barriers to the implementation of the framework in practice? How to overcome the barriers?

11- How likelihood the framework can be used to support your schools in PMMS?

☐ Definitely not

☐ Probably Not

☐ Possibly

☐ Probably

☐ Definitely

If there are any other issues which you feel are relevant to this research, please feel free to raise them now.

Thank you so much for your valuable contribution to the research!

Appendix G

List of Publications

- Le, A.T.H., Park, K.S., Domingo, N., Rasheed, E. and Mithraratne, N. (2018), "Sustainable refurbishment for school buildings: a literature review", International Journal of Building Pathology and Adaptation, Vol. 39 No. 1, pp. 5-19. https://doi.org/10.1108/IJBPA-01-2018-0009.

- Le, A. T. H., Domingo, N., Rasheed, E., Park, K. S. (2018). Building maintenance cost planning and estimating: A literature review. In Proceeding of the 34th Annual ARCOM Conference, ARCOM 2018 (pp. 697-706). Association of Researchers in Construction Management.

- Le, A. T. H., Domingo, N., Rasheed, E., Park, K. S. (2019). Effective property maintenance management for state-schools in New Zealand: issues and challenges. In CIB World Building Congress 2019, 17-19 June 2019, Hong Kong.

- Le, A.T.H., Domingo, N., Rasheed, E.O. and Park, K.S. (2020), "Building and property management framework for state schools in New Zealand", Facilities, Vol. 39 No. 3/4, pp. 172-195. https://doi.org/10.1108/F-11-2019-0126.

- Le, A.T.H., Domingo, N., Rasheed, E.O. and Park, K.S. (2021), Strategic Collaboration in Managing Existing Buildings in New Zealand's State Schools: Schools' Perspectives. Under-review, Construction Management and Economics journal.

- Le, A.T.H., Domingo, N., Rasheed, E.O. and Park, K.S. (2021), Maturity

model of building maintenance and property management in New Zealand's state schools. Accepted, Building Research and Information journal.

Appendix H

Statement of Contribution

DRC 16

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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	An Thi Hoai LE
Name/title of Primary Supervisor:	Dr. Niluka Domingo
In which chapter is the manuscript /published work:	Chapter 1+2

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Le, A. T. H., Domingo, N., Rasheed, E., & Park, K. S. (2018). Building maintenance cost planning and estimating: A literature review. In Proceeding of the 34th Annual ARCOM Conference, ARCOM 2018 (pp. 697-706). Association of Researchers in Construction Management.

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	
Date:	30-Mar-2021
Primary Supervisor's Signature:	
Date:	30-Mar-2021

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In which chapter is the manuscript /published work:	Chapter 2

Please select one of the following three options:

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- Please provide the full reference of the Research Output:

Le, A.T.H., Park, K.S., Domingo, N., Rasheed, E. and Mithraratne, N. (2018), "Sustainable refurbishment for school buildings: a literature review", International Journal of Building Pathology and Adaptation, Vol. 39 No. 1, pp. 5-19. https://doi.org/10.1108/IJBPA-01-2018-0009.

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Date:	30-Mar-2021

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Name of candidate:	An Thi Hoai LE
Name/title of Primary Supervisor:	Dr. Niluka Domingo
In which chapter is the manuscript /published work:	Chapter 4

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Le, A.T.H., Domingo, N., Rasheed, E.O. and Park, K.S. (2020), "Building and property management framework for state schools in New Zealand", Facilities, Vol. 39 No. 3/4, pp. 172-195. https://doi.org/10.1108/F-11-2019-0126.

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

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Date:	30-Mar-2021
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Date:	30-Mar-2021

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Name/title of Primary Supervisor:	Dr. Niluka Domingo
In which chapter is the manuscript /published work:	Chapter 4

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Le, A. T. H., Domingo, N., Rasheed, E., & Park, K. S. (2019). Effective property maintenance management for state-schools in New Zealand: issues and challenges. In CIB World Building Congress 2019, 17-19 June 2019, Hong Kong.

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	
Date:	30-Mar-2021
Primary Supervisor's Signature:	
Date:	30-Mar-2021

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Name of candidate:	
Name/title of Primary Supervisor:	
In which chapter is the manuscript /published work:	Chapter 4

Please select one of the following three options:

○ The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

◉ The manuscript is currently under review for publication – please indicate:

- The name of the journal:

Construction Management and Economics

- The percentage of the manuscript/published work that was contributed by the candidate: 70.00
- Describe the contribution that the candidate has made to the manuscript/published work:

An led the writing of the paper, collected data, analysed data, drafted the paper and revised the manuscripts according to supervisors' comments.

○ It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	
Date:	30-Mar-2021
Primary Supervisor's Signature:	
Date:	30-Mar-2021

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

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