A Sustainable Project Portfolio Selection Framework for IT Projects in Abu Dhabi Police

A thesis submitted for the degree of
Doctor of Philosophy

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To my beloved Parents, Wife,
Siblings and Children!

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Table of Contents

List of Appendices

Research Publications

Abdulla Al Mahri and Tariq M Khan, 2013, An Investigation into Sustainable Project Portfolio Management, *In Proceedings of the International Conference on Sustainable Human Development, iSHuD 2013, July 3rd to 4th 2013, London, United Kingdom, ISBN: 978-0-9576287-1-7.*

Abdulla Al Mahri and Tariq M Khan, 2014, Integrating sustainability into Project Portfolio Selection, Framework for IT Projects, *In Proceedings of the Second International Conference on Sustainable Human Development, iSHuD 2013, April 2nd and 3rd 2014, London, United Kingdom, ISBN: 978-0-9576287-2-4.*

Abdulla Al Mahri and Tariq M Khan, 2015, Towards the Development of a Sustainable Project Portfolio Selection Framework for IT Projects, *In Conference Proceedings of Academic International Conference on Business, Marketing and Management, (AICBMM 2015), Oxford, United Kingdom, ISBN: 978-0-9930368-8-0.*

Key Terms and Definitions

Criteria – any criteria, usually stated in a contract - includes deliverables, performance requirements or essential conditions, which must be met and be accepted.

Activity – The work or effort needed to achieve a result. An activity consumes time and usually consumes resources.

Activity Definition – Identifying the specific activities that must be performed in order to produce the various project deliverables.

Contingency Planning – The development of a management plan that identifies alternative strategies to be used to ensure project success if specified risk events occur.

Development – The actual work performed to develop the Information Technology Project.

Feasibility Study – A formal document in the Initiation Phase that analyses and discusses the technical feasibility of a project.

Leadership – The way in which the project manager influences the project team to behave in a manner that will facilitate project goal achievement.

Methodology – Used to define the processes, policies, and guidelines that are included as part of the framework for project management.

Policy – A succinct statement that gives direction to state organizations to support IT implementation. Policies are high-level, overall statements that do not dictate specific procedural steps or processes. Directives issued by management for guidance and direction where uniformity of action is essential.

Portfolio – A collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet objectives.

Portfolio Management – The centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives.

Project Planning – The process of developing broad-scope project documentation from which the technical requirements, estimates, schedules, control procedures, and effective project management will all flow.

Priority – The imposed sequences desired with respect to the scheduling of activities / projects within previously imposed constraints.

Procedure – Used to define a collection of steps that the organization is responsible for implementing to ensure that policies and process requirements are met. The agency may use guidelines to develop these procedures.

Project – A temporary endeavour undertaken to create a unique product or service.

Project Administration – Entails making Project Plan modifications that may result from such things as: new estimates of work still to be done, changes in scope/functionality of end- product(s), resource changes and unforeseen circumstances. It also involves monitoring the various Execution Phase activities, monitoring risks, status reporting, and reviewing/authorizing project changes as needed.

Project Duration – The elapsed time from project start date through to project finish date.

Project Initiation – A process that occurs before the organization has begun the Project Planning Phase and denotes a series of steps to have the project externally approved and started, including selection of the project manager.

Project Management – The application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements.

Project Manager – The individual appointed and given responsibility for management of the project.

Project Initiation Documentation (PID): The Project Initiation Documentation (PID) - one of the most significant artefacts in project management, which provides the foundation for the business project.

Abstract

In today's competitive business market where there is need to adopt business strategies and activities that meet the needs of the enterprise and its stakeholders, it is also important to protect, sustain and enhance human and natural resources that will be needed in the future. Such development is referred as a *sustainable development*, which includes all *social*, *environment* and *economic* aspects. In order to achieve sustainable development, the management of an organisation should incorporate an organisation's mission with respect to sustainable development to be served as a guideline for planning new projects. One of the key ways to achieve sustainable development is by prompting those organisational projects that cater for sustainability, and avoiding the ones that are damaging to sustainable development. In order to help in achieving this goal, this research devises a project portfolio selection framework that also caters for sustainability issues. Precisely, this research investigates a *Sustainable Project Portfolio Selection Framework for the selection of IT projects (SPPS-IT)*, which is determined by corporate strategy plan and by considering sustainability as the main optimisation factor. Moreover, the proposed framework also enables balancing of portfolio by considering sustainability and/or other evaluation factors. This development of SPPS-IT has been achieved by completing various key objectives such as: analyses of exiting project portfolio selection frameworks; determination of how sustainability can be integrated into a project portfolio selection framework; determination of the relationship between sustainability and other project portfolio selection factors; implication of taking sustainability as the main optimisation factor; and formulation of sustainable project portfolio selection policies. The developed SPPS-IT enabled the separation and execution of portfolio selection process into various distinct stages that included pre-processing, data/information flow, main process, post-processing and document stores. The SPPS-IT has been empirically evaluated in a case study organisation (Abu Dhabi Police) by working with a large number of portfolio managers and programmers. Moreover, a very large quantity of past and current projects' data have been sought, gathered and processed to assess the developed framework, approaches and methodologies in a rigorous but controlled manner. The implemented SPPS-IT process helped the portfolio managers to select project portfolios that maximised the criteria of interest of the organisation i.e. in line with their strategies, and which is also suitably balanced on both quantitative and qualitative parameters they chose. The research outcomes also provided the means to achieve a balanced portfolio of projects by proposing various portfolio-balancing policies. These portfolio-balancing policies can help portfolio managers in achieving a portfolio that met both the strategic and sustainability objectives of the organisation optimally.

Chapter 1: Introduction

This chapter introduces this research by identifying the problem domain and describes the motivation behind the work carried out in this research. The research aim, related research questions and research objectives that are achieved in this thesis are also presented. The research questions and related objectives have been presented with the use of argument diagram by focusing on the logical, evidential or inferential relationships among propositions. At the end of this chapter, a structure of this dissertation is outlined.

1.1 Background and Problem Statement

According to Johnson (2007), strategy is the "direction and scope of an organisation over the long term, which achieves advantage in a changing environment through its configuration of resources and competences with the aim of fulfilling stakeholder expectations". It can be notated from this definition that strategy is related to multiple actions in an organisation and an organisational 'strategy' and/or 'strategic decisions' are typically associated with various long- and short-term issues such as long-term direction, scope of activities, advantage over competition, strategic fit, resources and competences, values and expectations. Moreover, there can be various levels of corporate strategy in an organisation (Charlesmore, 2008); and thus, while looking into strategy, it is also important to look into its various levels. In an organisation, strategy can be related to overall corporate, business or just operations (Charlesmore, 2008). Each of these has different aims and objectives.

The top-level strategy that is usually concerned with the overall purpose and scope of an organisation is called *corporate-level* strategy. The corporate-level strategy also look-after the aspects related to value added services to various or all business unites of an organisation (Charlesmore, 2008). The major areas that are covered under Corporate-level strategy include resource management, business buying or selling decisions, project initiation and sustainability policy decisions. An organisation's corporate strategy is usually aligned with its *'mission statement'* that reflects its owner(s)' expectations. The second level of strategy concerned with actual business of an organisation is referred as *Business-level* strategy or competitive strategy. It is called competitive because this strategy is concerned with how to compete in particular markets on the basis of price, innovation, quality etc. In an organisation, a special unit called *"Strategic Business Unit"* usually prepares the Business-level strategy. Thus, the major difference between Business-level strategy and Corporate-level strategy is that corporate-level strategy involves decisions about the overall organisation and the strategic business unit(s) focuses on the business-level strategy (Fairholm, 2009).

It is important to note that for small to medium sized enterprises (SMEs) with only one type of business, the corporate strategy and the business-level strategy are could be the same (Nidumolu, 2013). However, when talking about '*sustainability'* it will still be associated with corporate-level strategy and thus it is useful to distinguish between them even for SMEs. In this case a corporate-level strategy can provide a

framework for whether and under what conditions new business opportunities or projects, such as IT development projects, might be added or rejected (Charlesmore, 2008). Moreover, organisational sustainability policies are mainly linked with corporate-level strategy.

Recently, there has been a great emphasis by many organisations to achieve sustainability by incorporating it in the corporate-level strategy (Nidumolu, 2013); however, what is included in this word "sustainability" is still vague for several organisations. For this dissertation, one of the most appropriate definition of sustainability for a business enterprise is given by the World Commission on Environment and Development that is: *"sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future"*. Overall, this definition is emphasising on two aspects, first-one is mostly done by every enterprise to benefit only them by adopting business strategies and activities, and the second-one emphases to extend this same idea to the world's natural and human resources.

Now the question is that how this can be achieved? And what is its relation with *corporate-level* strategy? As per the above definition, the idea of sustainable development needs to be integrated within organisational planning; and for this, the top management who are the maker of *corporate-level* strategy should be familiar with this. So that they are aware with the importance and can take actions to protect world's human and natural resources in-addition to physical and financial capital of their organisation.

Now, looking at the relationship between *corporate-level* policies and objectives to achieve sustainability, it is usually senior management who is responsible for defining sustainable development policies and objectives and expects their employees to follow them (Banerjee, 2002). Here, sustainable development includes all aspects of social, environment and economic. Thus, management should incorporate an organisation's mission with respect to sustainable development to be served as a guideline for planning. Krehmeyer (2010), highlights two main reasons of having a clear and comprehensive sustainability strategy for business leaders, which include *(1) knowing and communicating who you are; and (2) knowing where you're going*. Here the first reason implies that it is the responsibility of company executives to communicate and have an overall alignment across all organisation entities on the strategic goals. The second reason *"knowing where you're going"* is pointing towards achieving continuous reputation that is critical for long-term viability of an organisation, and for this, business leaders need to incorporate sustainability aspect into corporate-level long-term strategies. Thus, for business leaders, it is important to have a clear and comprehensive sustainability strategy incorporated into organisational corporate-level strategy. This research aims to resolve this problem by devising a suitable sustainable framework/*Mode*l of IT projects portfolio selection that will also cater for sustainability issues. To provide a viable solution to this problem the research aim, related research questions that have been formulated and the research objectives that are achieved to answer the research questions in this dissertation are presented in the next sections of this chapter.

1.2 Motivation

Since the establishment of the United Arab Emirates (UAE), the experience of sustainable development, reliance on the green economy and conservation of natural resources is on-going. The founding fathers of UAE's corporate had ambitious economic and social development plans and they took the environmental impacts of all projects into consideration. Through these efforts, these sustainable development practices became a model not only in the region, but in the international businesses. Among these, the late Sheikh Zayed bin Sultan Al Nahyan was one of the world's most prominent leaders to receive medals and certificates in the field of environmental conservation, including the award of the man of environment and development in 1993.

The establishment of sustainable development in UAE is an outcome of the vision of His Highness Sheikh Khalifa bin Zayed Al Nahyan, President of the UAE. Sheikh Khalifa bin Zayed Al Nahyan puts major focus on the importance of developing the national economy to a model in which development depends on knowledge, innovation and to provide employment opportunities for children. The emphases is on maintaining natural and environmental resources and enhancing the competitive position of the UAE in world markets.

Government of the UAE has seven priorities in line with the vision of the UAE 2021 to achieve the economic and social well being of its people. This is aimed at achieving sustainable development to reach the UAE in the developed countries. These seven priorities include a competitive knowledge economy, a sustainable environment, an integrated infrastructure, a high-quality health care system, a secure society, equitable justice, a distinct international status, a high-level education system and a cohesive society that maintains its identity.

The vision of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE has enabled the development of UAE Green Development Strategy. This strategy is developed under the theme of "Green Economy for Sustainable Development", which calls for a new phase in country's growth. In this way, UAE aims to be a globally successful model of sustainability by building a green economy. This green economy will eventually enhance UAE's competitiveness and growth and preserve its environment for future generations. The main objectives of this strategy are to build an environment-friendly economy and an environment that supports economic growth. The strategic features of the strategy are defined in six tracks covering various aspects of economic, social and environmental life, including green energy, green investment, green cities, climate change, green life and green technology. Under these parameters, the UAE government has been running many projects that include; for example (1) Masdar city – clean energy – this has made UAE world's third-largest solar energy producer; (2) Nuclear energy - critical driver of sustainable growth. With this UAE's peaceful nuclear program, the country will benefit from new energy sources. These new energy sources will provide environment friendly and abundant electricity for the operation of new industries and energy security. Thus, it will support direct economic growth by creating a modern industry that uses latest technology. Nevertheless, UAE also ensures the availability of a highly skilled national workforce to lead the future industry.

Moreover, UAE government through various departments such as Abu Dhabi Police is starting various IT projects nationwide. In this regard, Abu Dhabi Police itself receives several projects proposals from sub-departments. Due to various

organisational constraints, it is usually not possible to fund all projects and the decision makers based on number of factors including sustainability usually make this decision. The Abu Dhabi Police has sustainability strategy integrated with the corporate strategy to supervise on-going projects. However, it is a very difficult decision to select projects, as it requires consideration of many factors. Moreover, when there are various factors to be considered, coming up with balanced criteria becomes more challenging. This problem can be eased off with the use of a project portfolio selection framework, which can help the decision makers to follow a step-by-step approach for project selection. However, there isn't any implementation of a project portfolio selection framework; and therefore, project selection continued to be a difficult problem to solve at Abu Dhabi Police.

The research presented in this thesis in an effort in the same direction as discussed above to provide UAE; and in particular, Abu Dhabi Police with a sustainable PPS framework for the selection of IT projects.

1.3 Significance of the Proposed Research Area in Relation to Existing Research

Although, the detailed literature review related to this research is presented in Chapter 2, here the major related work carried out in this area to establish the significance and timeliness of the this research is described.

Project management is existent since long time but it was only recently accepted as a major management discipline (Maylor, 2010). That was the time when many project management tools came into existence, such as Gantt charts, that were quickly adapted by the corporate industries. Later was the start of project portfolio management era, as known today, which came into existence when originations went bigger and started operating globally. It was during late 1990s when researchers and project managers started to realise the strong need for a way to coordinate the project portfolio (Henriksen and Traynor, 1999), and to set the strategic priorities between various projects and find a balance between those projects (Madic et al., 2011). In (Birgisson, 2012), a study has been conducted and as per the results, it is only since 2007 when the project portfolio management / selection research became active. In particular, to best of our knowledge there is still no project portfolio selection framework along with practical case study exists that also caters for sustainability aspects for IT projects. However, there are some generic project portfolio selection frameworks, methodologies/ approaches and systems exist that have been extensively reviewed and compared in Chapter 2 of this thesis.

In a recent survey by Info-Tech Green IT Report (2013), sponsored by IBM a detailed investigation on the ways to achieve green and sustainable IT adopted by worldwide organisations has been presented. The outcomes of this survey report show that Green and Sustainable IT is being carried out in several areas that include (but not limited to) virtualisation, storage consolidation, IT energy measurement, equipment power management, printer consolidation, remote conferencing, IT equipment recycling, etc. Moreover, while looking at various Green IT adoption trends, such as in Info-Tech (2013) the four main areas where green IT and/or Sustainable IT is being adopted by the organisations include: *(1) virtualisation support and consolidation of storage space; (2) energy efficiency of IT equipment; (3) reduce travel by using remote conferencing and adopting telecommuting strategies; and (4) asset disposal – IT equipment recycling.* Therefore, the portfolio managers of organisations will have to consider most of all of the above ways to achieve a

sustainable project portfolio selection mechanisms for IT projects selection. Moreover, the organisations who have successfully implemented such initiatives suggest that success depends on following major factors: (1) having right and complete support of business stakeholders including top management as its require changes in processes, education of employees and a change in their attitude (Nidumolu, 2013); (2) it is usually the case that companies adopting green IT initiatives face various obstructions in the approval and implementation due to organisation culture, communication problems, lack of resources etc.; and (3) the current economic situation of concerning organisation i.e. revenues, Green IT budget or funding, prioritisation of projects etc. (Info-Tech, 2013).

Moreover, as per the review carried out of existing project portfolio selection *Mode*ls it has been concluded that most of the existing PPS approaches; for example, by (Khalili-Damghani et al., 2013) introduces a high-level project portfolio selection framework with abstract information on each component of the framework. Similarly, the project portfolio selection framework presented by Nasrin and Duecker, (2013) is mainly providing guidelines for organisations pursuing waste minimization, process optimization, or improvements in energy use. But, it is not considering how these (or other) sustainability factors can be incorporated into project portfolio selection framework. In another approach presented by Heising (2012), the proposed project portfolio selection conceptual framework is based on existing literature and interview questions and not by applying to a specific domain. In (Bernard and Sami, 2011) the benefits and shortcomings of the project portfolio selection methods are recognised to assist them with various choices, but not a complete design of project portfolio selection framework is proposed. Nevertheless, various other project portfolio selection abstract frameworks or theories have been presented; for example, by (Strang, 2011). However, in there is no project portfolio selection or project portfolio management framework is proposed which caters for sustainability aspects for IT projects. Recently in (Nowak, 2013), an idea has been formulated within which a new universal method for project portfolio selection could be designed. However, this is an in-progress work and in future authors plan to propose a dynamic interactive decision support technique combining a decision tree and interactive approach. The closest literature found during this literature review was in (Abbassi et. al., 2013) where a multi-stage decision framework of research and development (R&D) project portfolio selection is provided which has four major modules i.e. research projects categorization; identifying research projects evaluation criteria; constructing mathematical *Mode*l; and research projects evaluation and constructing R&D project portfolio. However, it is not clear that to what extent and how sustainability aspects can be catered-for in the framework, if any.

1.4 Principals of Sustainability

Sustainability is to accomplish the preservation of asserts for future generations, which humans are presently appreciating (United Nations, 1987). Today, sustainability is becoming one of the most important topics of discussion in our organizations especially with respect to management as it affects all kinds of industry or business (Garcez, 2013). Recently, there has been a great emphasis by many organisations to achieve sustainability. When talking about principals of sustainability, they are usually articulated in a general fashion. However, the principals of sustainability are of attention when they are looked in relation to sectors such as economy, development issues, business strategies or initiatives taken by

individuals or organisations. In general, the set of three Sustainability Principles i.e. *environment*, *social*, and *economic* factors and the need to balance between them are related to business enterprises. According to Epstein (2008), there could be other various sustainability factors which can be incorporated to management and businesses e.g. ethics, governance, community involvement, economic development, value of services, employment practices and protection of the environment. Moreover, these sustainability factors should be considered into routine management decisions in both operation management and investments (Davies, 2008).

The implementation of the "principals of sustainability" or "sustainable development" has two parts, one is to make development in a way that used recourses meet human needs; and two, ensure the sustainability of nature and environment to meet the needs of both present and future generations. Looking at the *Leadership Council* of the Sustainable Development Solutions Network (2013), they have given more analytical breakdown to the notion of sustainable development and distinguish sustainability to economic, ecological, political, and cultural as well as good governance. However, most of the literature refers sustainable development in three domains i.e. *environment sustainability*, *social sustainability* and *economic sustainability* (Wang, 2010). In the following paragraph, an introduction these three environments, social and economic domains of sustainable development are provided and more details are specified in the Chapter 2 of this thesis.

To move towards achieving sustainability, the first default step is to build a sustainability policy. There could be many reasons to build a sustainability policy and one of the main reasons could be that a company was wasting resources in the past now they want to avoid it. Sustainable development can benefit to the society in several ways including the social, environmental and economic paybacks (Hart, 007). Moreover, a balanced sustainability policy must accommodate all three social, environmental and economic aspects of sustainability in it (Samantha et al., 2011). Here, the *"Economic Sustainability"* safeguards fair distribution and efficient allocation of resources. In short, economic sustainability does make sure that the business makes profit, but without creating social or environmental issues that would harm the long-term success of that business. The "*Environmental Sustainability"* supports things like reducing emissions, sustainable agriculture, recycling and waste management etc. The "Social *Sustainability"* looks after the well being of people and do not support human inequality and poverty (Thampapillai, 2010); for example, wellness of communities around factories etc. These principals or three pillars of sustainability do have their individual importance; however, taking a balanced approach to sustainability has grater advantages and each pillar often supports each other (Samantha et al., 2011). Therefore, in this research these three pillars of sustainability i.e. *Economic,* Social and *Environmental are considered.* Going deep into the concept of sustainability, Chapter 2 reviews the state of the art literature in this domain and discuss the link of sustainability with an organisation goals and strategies. In the next section, research aims, questions and objectives are discussed.

1.5 Research Aim, Gaps, Questions and Objectives

This research aims

"To develop a sustainable PPS framework for the selection of IT projects, which is determined by corporate strategy plan and by considering sustainability as the main PPS optimisation factor along with balancing it with other PPS factors".

The main research question of this research aim is:

"How can the PPS framework be improved for the selection of value added projects based on a balance approach to sustainability that is determined by both corporate and sustainability strategies?"

In an effort towards achieving the above defined research aim, the main research question of this research has been decomposed into further research questions and their associated objectives based on the identified research gaps. As a result the following 5 refined objectives and research questions are articulated, which are described in this section also with the help of diagrammatic argument diagrams.

1.5.1 Research Question and Objective 1

In general, there are various simple methods exist to evaluate sustainability in a project portfolio; for example, sustainability evaluation checklist method (Schroter, D., 2010). The sustainability evaluation checklist method can be used in planning and designing project and program evaluations of sustainability for sustainability. However, this method is not applicable for all types of projects as not all components in the checklist are relevant in all situations being considered in a portfolio (Schroter, D., 2010). Thus, this method needs strong engagement in discussions with stakeholders, which influences to determine which aspects are of special importance. Another traditional method used to evaluate sustainability in a project portfolio selection is through generating a sustainability value map (Butters, C., 2004). In this method sustainability is evaluated and presented in the form of a value map, which can be used to make comparative studies between projects. In its simplified form, it provides a checklist for discussion amongst stakeholders and in its detailed form it gives a complete qualitative and quantitative picture of the condition of all projects in a portfolio (Butters, C., 2004).

In the recent years, multi-criteria decision analysis has been widely applied to a variety of systems (as described in Jeon CM, Amekudzi AA, Guensler RL. 2013) for integrated sustainability assessment and having been used at both the project and planning levels. The application of multi-criteria decision analysis methods have become increasingly popular in decision-making for sustainability because of the multi-dimensionality of the sustainability goal and the complexity of the different systems included in the assessment (Jeon et al., 2013). However, these methods provide only abstract ideas and evaluation indicators without any practical case study implementation. In the existing literature, while developing a framework for sustainability and selecting sustainable development indicators two distinctive main approaches are usually used i.e. (a) the *'top-down'* approach, which enables experts and researchers to define the overall structure for achieving the sustainability and subsequently it is broken down into set of indicators, and (b) the *'bottom-up'* approach requires systematic participation of various stakeholders to understand the framework as well as the key sustainable development indicators (Rajesh Kumar Singh, H.R. Murty, S.K. Gupta, A.K. Dikshit, 2012).

After reviewing the above and related literature it was found that there is an existence of abstract-level conceptual ideas on decision-making frameworks for sustainability. However, to best of our knowledge only limited existing literature describes how sustainability can be considered in a project portfolio selection

evaluation stage which selecting IT projects. Thus, the following research question and objective 1 was formulated (as depicted in Figure 1.1):

Research Question 1: To what extent the existing PPS frameworks are suitable for integrating sustainability?

In order to answer the above research question the following objective was planned:

Research Objective 1: To review and analyse the exiting PPS frameworks in order to establish the possibility for incorporating sustainability for the evaluation of IT projects.

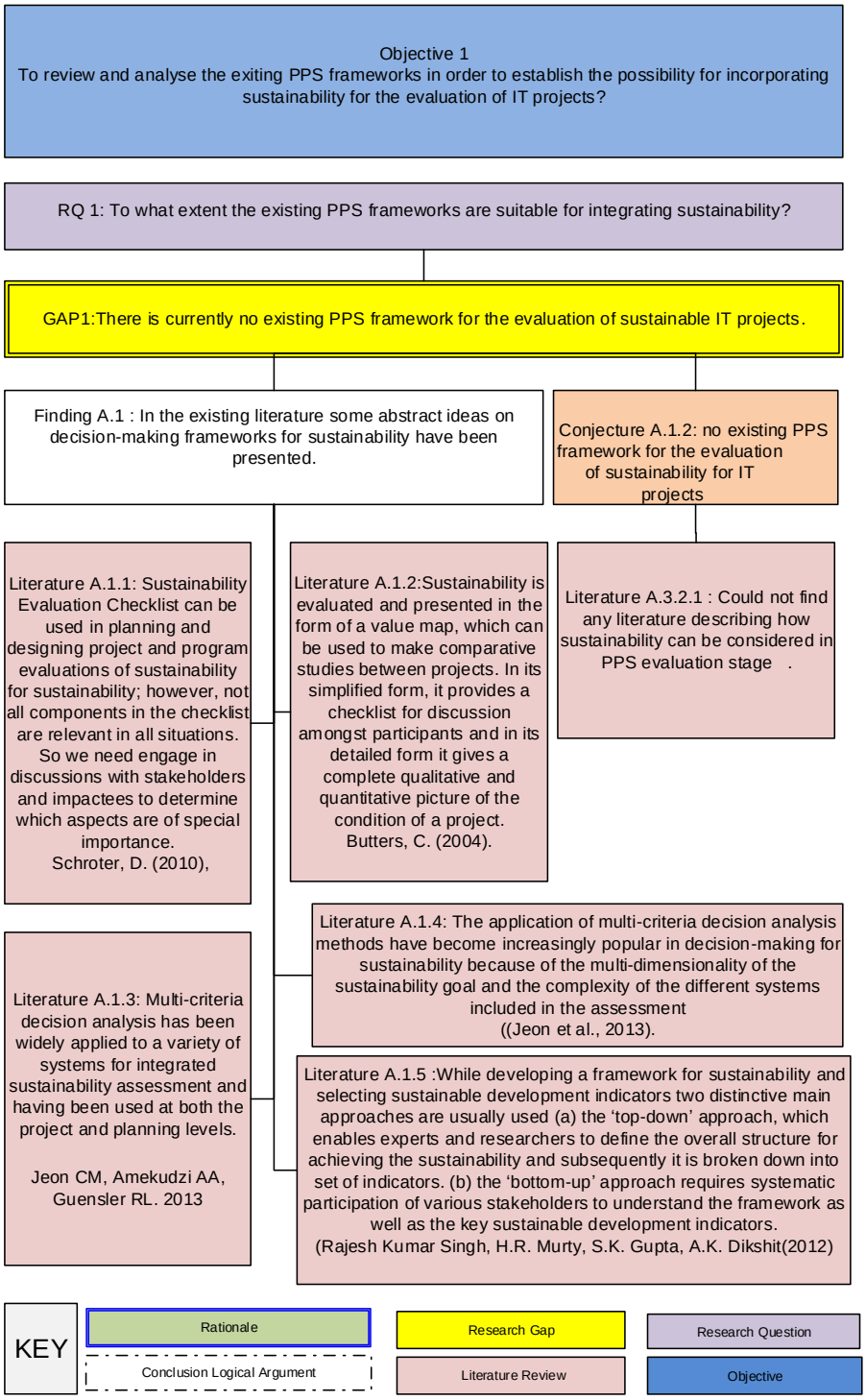


Figure 1.1: Research Question and Objective 1

1.5.2 Research Question and Objective 2

The concept of sustainable project has been an important focal point for the decision makers in the industry. Sustainability assessment helps decision-makers and policy-makers to decide which actions or projects they should or should not take in an attempt to make society more sustainable (Cesar A. Poveda & Michael G. Lipsett, 2014). According to KEI (2005), "Indicators and composite indicators are increasingly recognised as a useful tool for policy making and public communication

in conveying information on countries' performance in fields such as environment, economy, society, or technological development".

Some of the goals of sustainability assessment through sustainable development indicators are to anticipate and assess conditions and trends, provide early-warning information to prevent economic, societal, and environmental damage, and support decision-making (Poveda and Michael, 2014). In order to accept or reject a project based on early warning a "pre-project and / or initiation" phase can be used while integrating sustainability into project portfolio selection (Carboni et al., 2013). Therefore, sustainability considerations must be included in project decision making in order to make society more sustainable and to prevent economic, societal, and environmental damage of running projects. Thus, an integration of sustainability assessment into project portfolio can help in making a society more sustainable. The resultant developed *Mode*l can help to select a project portfolio that maximizes the criteria of interest of an organisation, that is inline with cooperate strategy and sustainability strategy, and which is also suitably acceptable on both quantitative and qualitative parameters chosen by that organisation.

These above findings led us to formulate the following successive research question and objective 2 (as depicted in Figure 1.2:

Research Question 2: How can sustainability be considered as an evaluation stage in a PPS framework?

In order to answer the above research question the following objective was planned:

Research Objective 2: Determine how sustainability can be integrated into a PPS framework as a stage for the evaluation of IT projects.

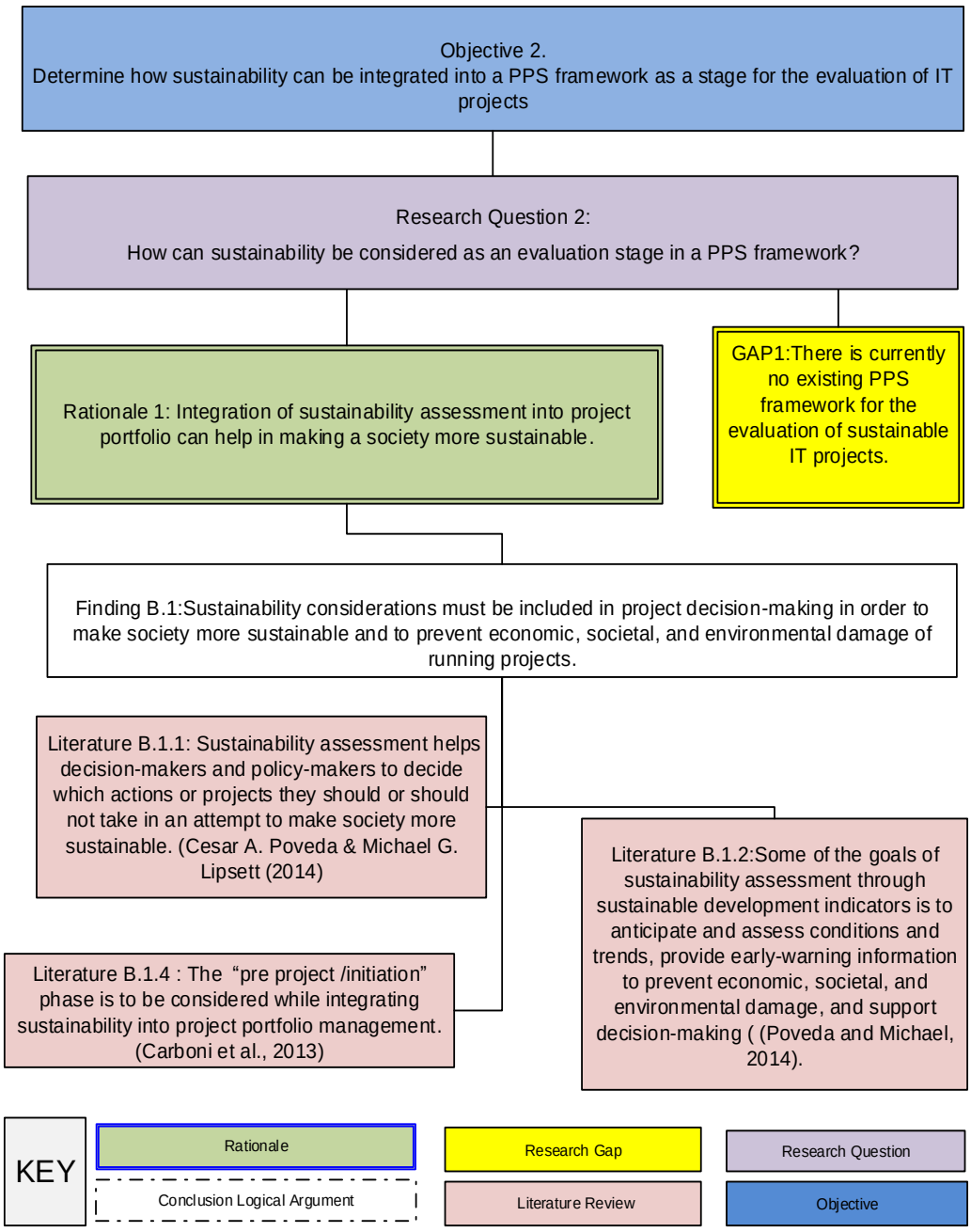


Figure 1.2: Research Question and Objective 2

1.5.3 Research Question and Objective 3

Within an organisation usually there are a number of interesting, challenging projects to choose from. However, finding a project that is the right fit for your organisation's team's skillset, competence level, and affords the best chance of success is the first step in effective project management. Once a project proposal has been received, there are several factors that demand to be considered before an organisation decides to take that project up. The most worthwhile alternative needs to be chosen, keeping in mind the ambitions and necessities of the organisation. According to Eilertsen, S. (2014), in project portfolio selection, project selection is based on meeting the organisation's objectives. Project portfolio selection provides a framework for under what conditions new projects can be added or rejected (Archer, Ghasmzadeh 1999). Project portfolio selection is not an easy task as it involves consideration of various alternatives and balancing between them. Therefore, in a project portfolio selection framework, decision makers usually have to face a budget, allocated time and various other constraints when they have to decide which projects are going to be undertaken to satisfy their requirements and guarantee profitable growth (Perez, F. and Gomez, T., 2014). As recognised by Khalili-Damghani et. al., (2013), "a comprehensive framework which considered risk, sustainability, organisational, and strategic aspects of a project selection has not been considered in literature of project selection". However, there are various guidelines on what aspects a project portfolio selection framework should consider. For example, as stated by Mckinlay (2008), a project portfolio selection is to be carried out without violating constraints put by corporate strategy. Moreover, organisations should not loose the major motivation or objective behind project portfolio selection that is to select the right projects in terms of strategic objectives, time, cost, scope and resources (LE.CM 2008).

In the above arguments / literature it was found that in the existing literature there has been considerations of various factors (such as time, resources and cost) in a project portfolio selection to achieve an organisation's strategic objectives. In order to consider sustainability as one of the project portfolio selection framework decision making factors, a sustainable project portfolio selection framework is needed that can incorporate sustainability factor along with other project portfolio selection factors. This finding has let us identify the gap in the literature that there have been limited considerations of incorporating sustainability as an ordinary project portfolio selection factor for the selection of IT projects (as depicted in Figure 1.3).

In the past, it has been a general understanding (or to some extent a judgment) that if there were several projects assigned to a project manager, the project that has the highest economic value added was picked. These economic values added have been mostly expressed in numerical terms. Recently, this phenomenon has been changing. Today while choosing projects, in addition to highest economic value added, organisations does recognise sustainability as an opportunity to make its operations more efficient and robust (Marisa Analía Sánchez, 2014). The adoption of comprehensive project selection techniques such as using project portfolio selection allows selecting the better mix of projects. These selections are usually based on the simultaneous analysis of eco-impacts and contribution to organisational goals, and by integrating sustainability can further help to solve a decision problem to support the project selection and monitoring (Marisa Analía Sánchez, 2014). Moreover, in the recent year, there has been vast recognition of the benefits and importance of integrating sustainability as a major factor in the project portfolio selection process.

This is being seen as organisational reputation and it is imperative that organisations improve their sustainability and there is a global push to reduce the environmental impact from project activities. Due to such causes, sustainability considerations must be included in project decision-making frameworks to address the global requirement to improve the environmental impact of project activities and their outcomes (Hiyam Al-Kilidar, Steven Davis, Cat Kutal, Catherine Killen, 2011). Overall, the above literature has enabled us to determine that integrating sustainability as a factor in project selection can help in decision making to support the global requirement to improve the environmental impact of project activities and their outcomes. Thus, it would be a logical argument to make here that considering sustainability as a factor in project decision-making can lead towards the selection of greener projects (as depicted in Figure 1.3). These above has led us to formulate the following successive research question and objective 3:

Research Question 3: How can sustainability be balanced with other factors and cost when all of these are collectively considered as PPS factors?

In order to answer the above research question the following objective was planned:

Research Objective 3: Determine the relationship between sustainability and other IT project portfolio selection factors.

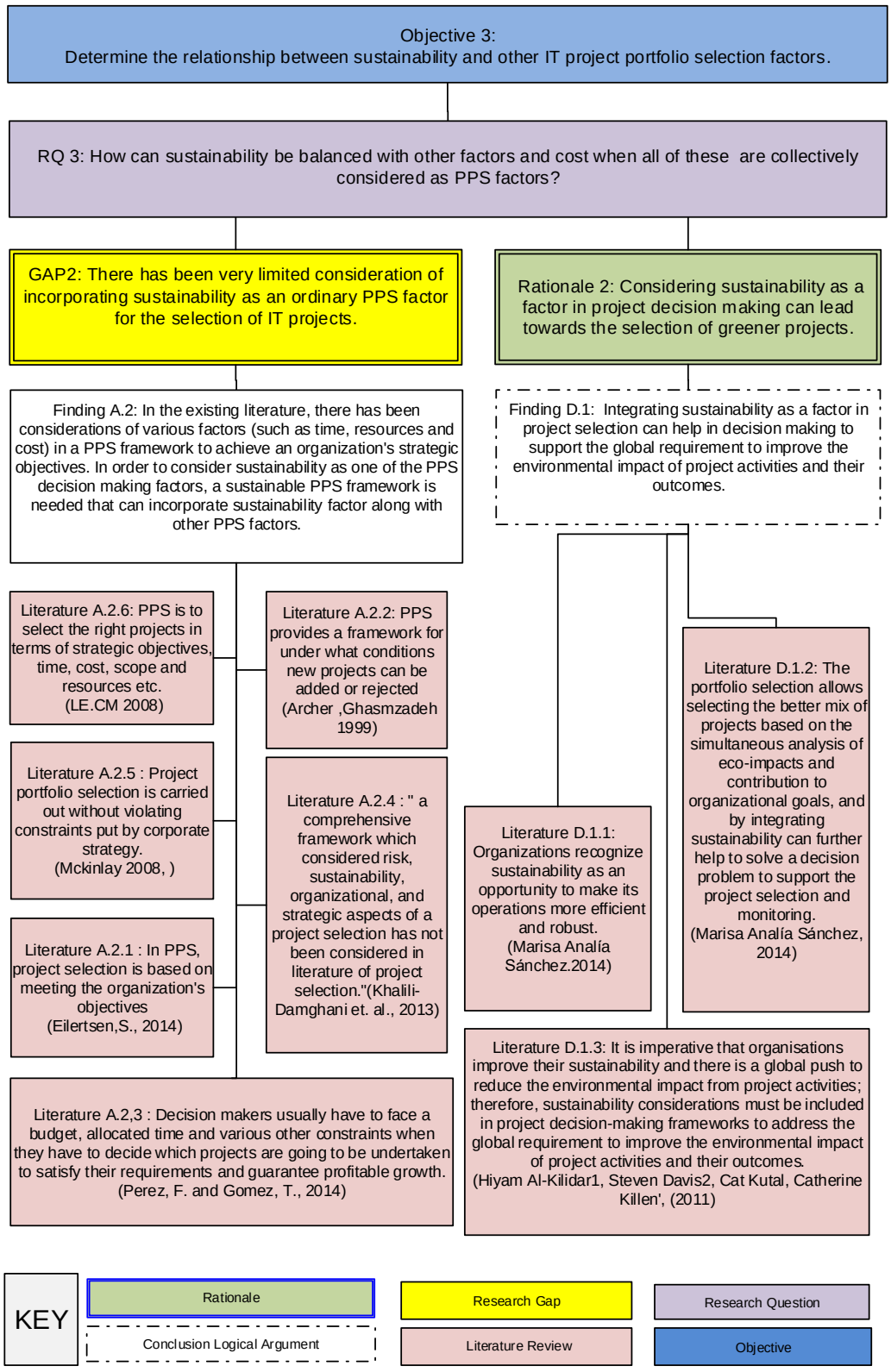


Figure 1.3: Research Question and Objective 3

1.5.4 Research Question and Objective 4

One of the major steps in project portfolio selection is the portfolio optimization. The portfolio optimisation is the process of choosing the proportions of various properties to be held in a portfolio, in such a way as to make the portfolio healthier or balanced. According to T. J. Chang et. al. (2009), expect return and risk are the important parameters with regard to portfolio optimisation problems. Although most of the proposed projects in an organisation are important, but due to the research and development budget constraints and limited resources, firms are often forced to select a subset of all candidate projects (M. Abbassi et. al. 2014). This selection of a subset from all candidate projects is usually done by means of project portfolio selection techniques mitigating the corresponding risks and enhancing the overall value of portfolio (M. Abbassi et. al. 2014). In general, once an organisation has the defined target portfolio with all projects, then they can get a portfolio that is "close" to the target but does obey the constraints. The purpose of project portfolio decision is to allocate a limited set of resources to projects in a way that balances risk, reward, and alignment with corporate strategy (Wang J. et. al., 2007). Thus, the above literature informs that organisations can have different optimisation factors to balance project portfolio selection. Moreover, sustainability for IT projects selection is not considered in the existing project portfolio selection frameworks; and thus, a viable mechanism to add sustainability as an optimisation factor needs to be explored. Furthermore, there is a gap in the existing literature that how to balance sustainability with other various project portfolio selection factors by taking sustainability as a main optimisation factor for the selection of IT projects (as depicted in Figure 1.4).

Moreover, for many organisations economic analysis is the most common used criteria of investment assessment in the classic decision making procedures used in the project portfolio selection methods. The use of sustainability factor in project portfolio selection, which considers the balance of economic, social, and environmental effects of an investment, concurrently, is a *Mode*rn paradigm (Kaveh Khalili-Damghani, Soheil Sadi-Nezhad, 2013). Issues such as global climate change, poverty, inequity and the unsustainable use of resources are driving organisations to incorporate the principles of sustainable development into corporate strategy; and therefore, sustainability should be an integrated part of project portfolio to support and achieve the objectives of an organisation. (Alex John Hope, Robert Moehler, 2014). Thus, the existing literature endorses the importance of adding sustainability as a factor in project portfolio selection for decision making by the organisations. This does not mean that various other factors (such as risks, resources etc.) became less important, sustainability should be considered as an integral part of project portfolio. In return, considering sustainability as the main optimisation factor of project portfolio selection can help to achieve a sustainable society.

These above has led us to formulate the following successive research question and objective 4:

Research Question 4: How can sustainability be included in a project portfolio selection framework as the central optimisation factor for the selection of IT projects?

In order to answer the above research question the following objective was planned:

Research Objective 4: Determine the relationship between sustainability and other project portfolio selection factors by taking sustainability as the main optimisation factor.

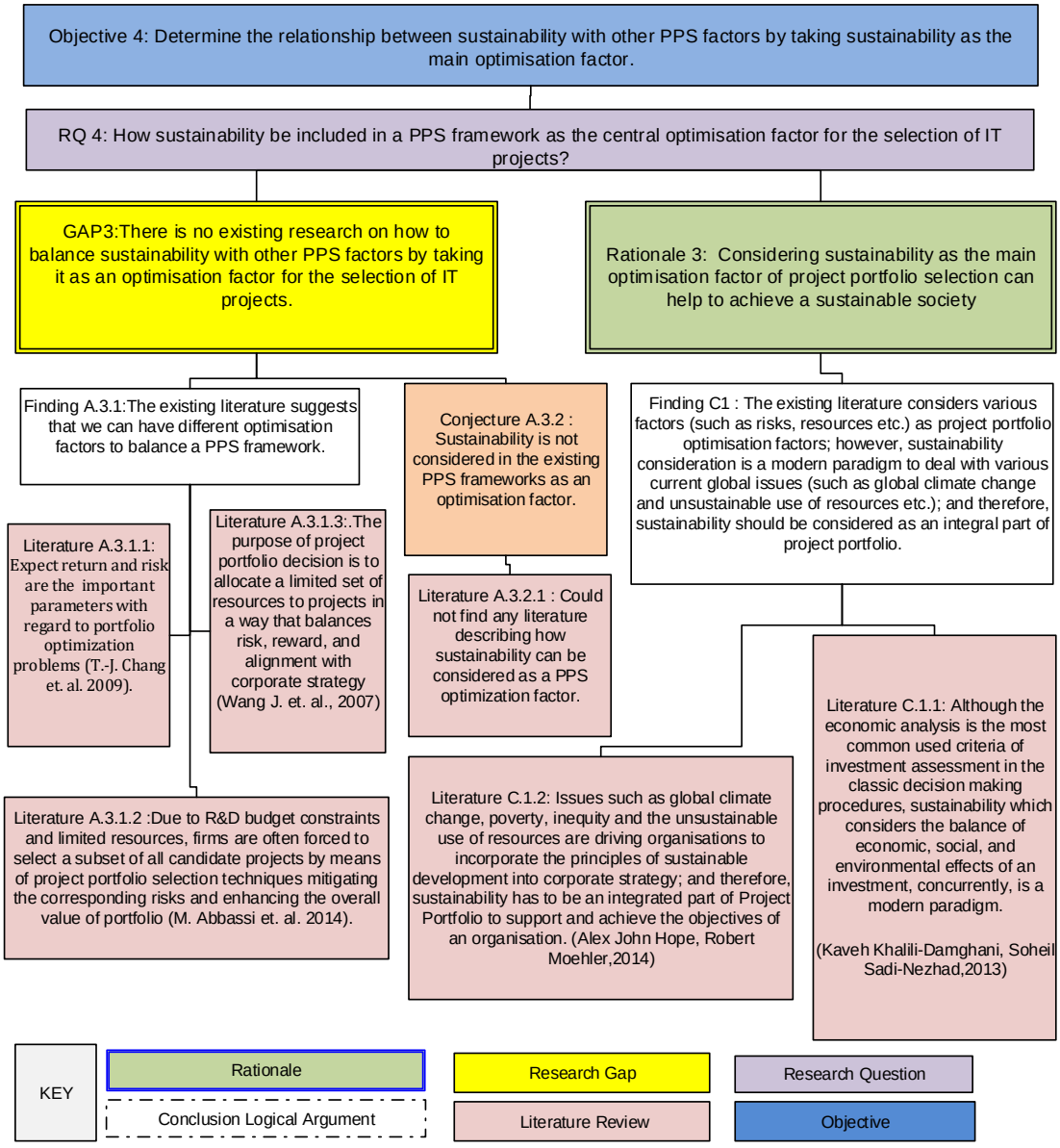


Figure 1.4: Research Question and Objective 4

1.5.5 Research Question and Objective 5

Many organisations are now considering integration of sustainability principles into their projects selection methods and product development. In general, organisations are doing so to pursue goals that go far beyond the usual concern for organisational reputation management — for example, saving natural resources, saving energy, achieving green IT, all of which can help organisations capture value. In order to make this integration of sustainability a reality, Project, Programme and Portfolio managers should plan and build a sustainable policies and approaches. These sustainable policies and approaches should attempt to maximise resources in the most efficient way, including the use of natural recourses, thus providing the

benefits required to convene the anticipations of stakeholders (*Alex John Hope, Robert Moehler 2014).*

Integration or development of sustainability principals or policies can require various phases. As argued by *Butler, Y., (2008),* an organisational strategic intent developed in the Strategy Formulation phase, is translated in the Strategic Portfolio Definition phase, to identify a portfolio of strategic initiatives that is then scoped into themes, programs and priorities for the selection of projects. Thus, overall project portfolio selection should be considered as a process that includes various stages and sustainability evaluation is to be included as one stage. In the past project portfolio selection included stages such as: pre-process stages to get guidance of the portfolio selection process, strategy development for strategic focus / setting resource constraints, methodology selection / choosing the techniques to use for portfolio selection (F. Ghasemzadeh, N.P, 2000). The existing literature informs us that there are various existing techniques to implement portfolio policy for project selection (reviewed in detail in Chapter 2); however, the most commonly used method is manual translation and verification of portfolio policy whose results are consulted by the selection team for their decision making on project portfolio selection. Moreover, to best of our knowledge there is limited literature describing how sustainability policies can be linked to project portfolio selection framework for IT projects (as depicted in Figure 1.5).

While investigating sustainability strategy development roles and responsibilities in an organisation, it emerges that it is the responsibility of business leaders to have a clear and comprehensive sustainability strategy (Rangan K.,Chase,L.A,S., 2012). The organisational sustainability strategy is then forwards to the lower levels in an organisation, which is implemented by the project portfolio managers. Also, an organisational corporate- level strategy looks after the value added services to various or all business unites of an organisation and there has been a great emphasis by a number of organisations to achieve sustainability by incorporating it in the corporate-level strategy (Krehmeyer 2010,Charlersmore 2008). According to Krehmeyer (2010), to achieve continuous reputation business leaders have to incorporate sustainability aspect into corporate-level strategies. This is because; there is a demonstrable coherent and supporting relationship between the project portfolio and the business strategy and policies, for example ethics and sustainability. Therefore, to achieve success, project portfolio must demonstrate how this sustainability is effectively addressed (Hope A. J. et. al., 2014). The above literature gives us the findings that a clear and comprehensive sustainability strategy needs to be incorporated into organisational corporate-level strategy by the business leader in order to achieve sustainability (as depicted in Figure 1.5). The justification of this is that at corporate governance level sustainability is accepted as a source of success; therefore, integration of sustainability policy within corporate-level strategy as the central optimisation factor for project portfolio selection can lead towards achieving corporate objectives and continuous reputation.

In order to address the above-identified research gaps, this thesis develops a comprehensive sustainable project portfolio selection framework along with sustainable project portfolio policies that outlines strategies and mechanisms for considering sustainability in IT projects portfolio selection. These has led us to formulate the following successive and final research question and objective 5:

Research Question 5: How to determine sustainable portfolio policy for IT projects selection, which integrates both organisational strategic objectives and sustainability strategy?

In order to answer the above research question the following objective was planned:

Research Objective 5: Formulate sustainability project selection policy, which incorporates both corporate level strategy and sustainability strategy.

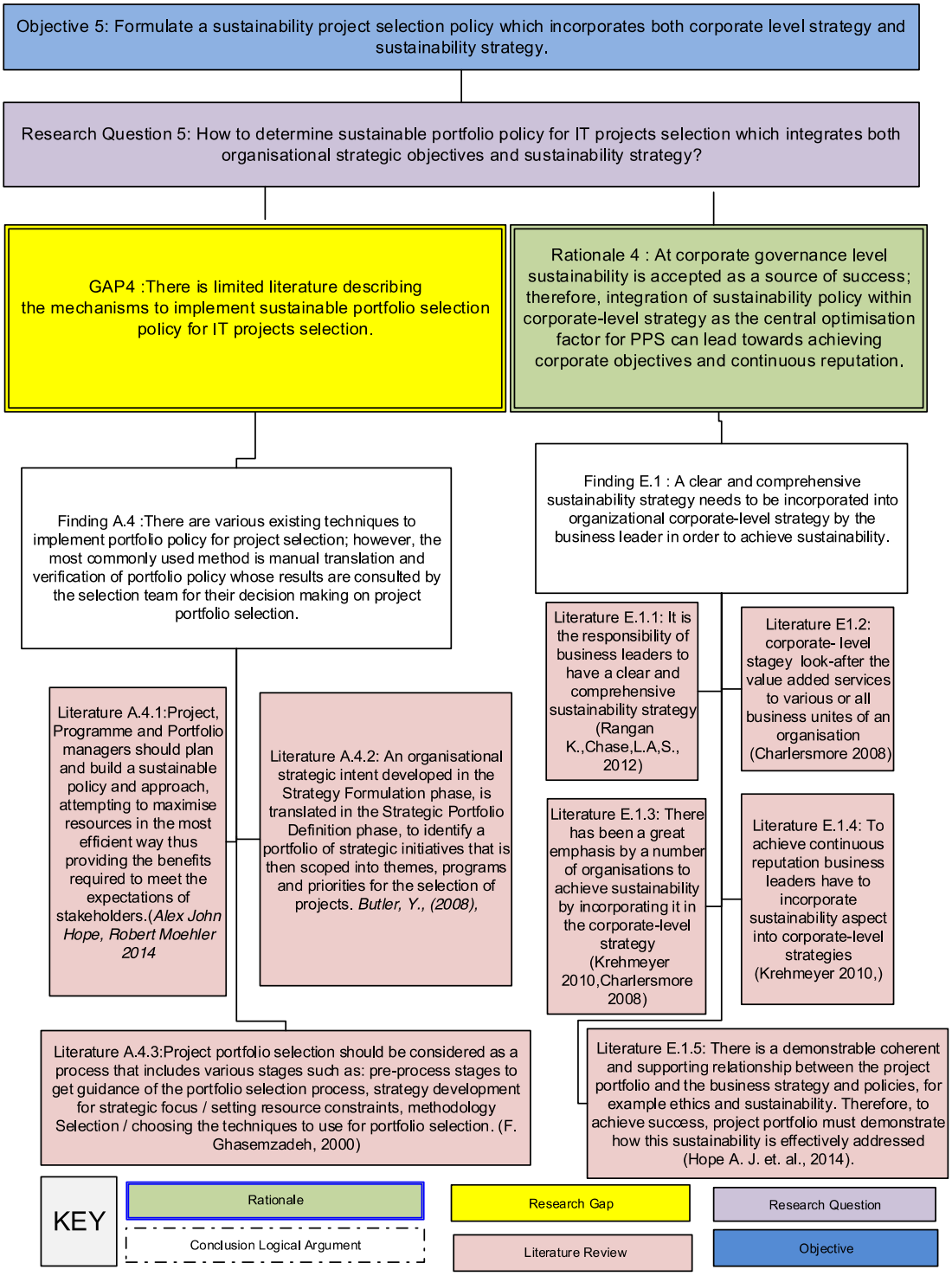


Figure 1.5: Research Question and Objective 5

1.6 Thesis Structure

This chapter 1 introduced the problem domain, significance of the proposed area and the need to investigate the integration of sustainability into project portfolio selection framework for the selection of IT projects. After providing a background, the research aim, related research questions and the research objectives that are achieved to answer related research questions in this thesis have been presented. The identified research gaps has been extensively investigated and presented with the use of argument diagram by focusing on the logical, evidential or inferential relationships among propositions. Following is the outlined structure of this thesis.

The Chapter 2 provides background and state-of-the-art review of the undertaken research area. The main elements of the reviewed literature include corporate strategy, sustainability, role of sustainability policy in an organisation, different ways to achieve green and sustainable IT, the relationship between sustainability and project management, project portfolio management and project portfolio selection – including their differences and commonalities, critical evaluation of existing project portfolio selection methods, detailed comparative review on project portfolio selection *Mode*ls that attempted to include sustainability as a factor. Finally the chapter concludes with a discussion on the need of implementing a sustainable project portfolio selection framework for the selection of IT projects.

The Chapter 3 of this dissertation explains the research methodology in detail along with the fine-grained activities performed to achieve the research objectives. In regards to this, the chapter starts with the introduction and provides a comparative analysis of available / suitable research methodologies. Next, the chapter justifies the selected methodology along with the diagrammatic and textual description of methodology. Detailed activities diagrams' are also provided presenting activates that have been carried out to achieve the defined research objectives of this dissertation. Then, the chapter focuses on empirical data collection and data analysis methods used in the research.

The Chapter 4 provides details on the development of a sustainable project portfolio selection framework for the selection of IT projects on the basis of theoretical foundation established in this research.

The Chapter 5 provides details on empirical evaluation and research findings. The scenarios evaluation details and results obtained from the experiments are presented and discussed in this chapter. This chapter also include details on data collection and their methods, provides all scenarios real-life data collected from the case study organisation, the selected scenarios and their outcomes, data analysis details and their outcomes. Finally the chapter discusses and concludes overall findings of conducted empirical research and per the initially defined research questions.

The Chapter 6 presents analysis and findings. These analysis and findings are presented in relation to the research questions and objectives of this research.

The Chapter 7 is the final chapter of this dissertation that outlines conclusions. This chapter also identifies research limitations and accordingly informs various future research directions.

Chapter 2: Literature Review

This chapter present the summarised outcomes of detailed literature review that has been carried out in this research. In this regard, the Section 2.1 introduces the concept of strategy, various levels of strategy in an organisation and highlights the sustainability aspects that are usually related to an organisational strategy. In Section 2.2, the concept of sustainability and sustainability development are highlighted. This section also present concise review of the existing literature on the role of sustainability in an organization; and the need for balancing it as per the environment, social, and economic factors. Due to the rapid increase in energy costs and awareness of climate change, green and sustainable IT has been getting high interest, especially among those organisations who spend huge amount on their IT infrastructures. Thus, such organisations have been looking for business strategies to reduce their environmental impact. Over the years, organisations have adopted several Green IT approaches and innovative solutions to reduce energy consumptions, reduce travel costs and make their procurement practices green. In this regard, Section 2.3 presents conventional ways to achieve green and sustainable IT. Section 2.4 focuses on project management, with a major focus on the comparison between the sustainability and the project management aspects; and nevertheless, how they are related or different. As this research particularly focuses on project portfolio selection and how to include sustainability aspects in it, Section 2.5 first reviews some of the basic difference between project management and project portfolio management. This is followed by the detailed state of the art comparative review on project portfolio selection models or frameworks in Section 2.6. This review of existing project portfolio selection models had main objectives to identify the extent of current research on such models and incorporation of sustainability aspect to achieve green IT. Furthermore, to summarise these findings, Section 2.7 presents a comparison table of all related project portfolio selection frameworks in terms of their features, application domain, benefits and limitations etc. Finally, the conclusions of the literature review are presented in Section 2.8.

2.1 The Concept of Strategy

This section introduces concept of strategy, various levels of strategy in an organisation and highlight the sustainability aspects that are usually related to an organisational strategy. Johnson (2007) defines strategy as the *"direction and scope of an organisation over the long term, which achieves advantage in a changing environment through its configuration of resources and competences with the aim of fulfilling stakeholder expectations"*. It can be notated from this definition that strategy is related to multiple actions in an organisation and an organisational 'strategy' and/or 'strategic decisions' are typically associated with various long- and short-term issues that are summarized as follows:

Table 1: Summary of corporate strategy related things and typically associated issues

Organisational Strategy and/or Strategic Decisions	Properties or Related Issues
Long-term direction	Where a strategic change in an organisation requires a lengthy time-scale to implement.
Scope of activities	Where the organisation concentrates on one main and big area of activity, or over too many different (may be tiny) activities.
Advantage over competition	Where organisations concentrate on not losing its advantages by competitors *(e.g. by other competing faster-growing companies).* This may be achieved in different ways.
Strategic fit	Where organisations need appropriate *positioning* in their business environments.
Resources and competences	Where an organisation fully exploits their resources and competences, to provide reasonable advantage and bring new opportunities.
Values and expectations	Where the long-term direction of an organisation is considered to meet the expectations of all (or main) actors.

Moreover, there can be various levels of corporate strategy in an organisation (Charlesmore, 2008), which are discussed in the following section.

2.1.1 Levels of Strategy in an Organisation

Strategies exist at several levels in an organisation; and thus, while considering strategy, it is also important to consider its various levels. In an organisation, strategy can be related to overall corporate, business or operations (Keyes, 2016). Each of these has different aims and objectives that are reviewed here.

The top-level strategy that is usually concerned with the overall purpose and scope of an organisation is called *Corporate-level strategy*. The Corporate-level strategy also look-after the aspects related to value added services to various or all business unites of an organisation (Charlesmore, 2008). The major areas that are covered under *Corporate-level* strategy include resource management, business buying or selling decisions, project initiation and sustainability policy decisions. An organisation's corporate strategy is usually aligned with its *'mission statement'* that reflects its owner(s)' expectations.

The second level of strategy concerned with actual business of an organisation is referred as *Business-level* strategy or *competitive* strategy. It is called *competitive* because this strategy is concerned with how to compete in markets based on price, innovation, quality etc. In an organisation, a special unit called "Strategic Business Unit" usually prepares the *Business-level* strategy. Thus, the major difference between *Business-level* strategy and *Corporate-level* strategy is that corporate-level strategy involves decisions about the overall organisation and the strategic business unit(s) focuses on the business-level strategy (Fairholm, 2009).

It is important to note that for small to medium sized enterprises (SMEs) with only one type of business, the corporate strategy and the business-level strategy are could be the same (Nidumolu, 2016). However, when talking about sustainability it will still be associated with corporate-level strategy and thus it is useful to distinguish between them even for SMEs. In this case a corporate-level strategy can provide a framework for whether and under what conditions new business opportunities or projects (such as IT development projects) might be added or rejected (Keyes, 2016). At the last level of organisational strategies are operational strategies, which are

concerned with actual working to effectively deliver the corporate-level and business-level strategies in terms of resources, processes and people (Charlesmore, 2008). Thus, operational strategies are dependent on the corporate-level and business-level strategies.

It can be concluded from the above discussion that organisational sustainability policies are mainly linked with *corporate-level* strategy and implemented in the operations level. Next section discuss various sustainability aspects that are related to corporate strategy and vice versa.

2.1.2 Corporate Strategy and Sustainability

Historically sustainability is defined as *"a requirement of our generation to manage the resource base such that the average quality of life that we ensure ourselves can potentially be shared by all future generations"* (Geir, 1994). Geir (1994) also defined that: *"development is sustainable if it involves a non-decreasing average quality of life"*. Moreover, according to the European Commission Directorate-General Education and Culture: *"a project is sustainable when it continues to deliver benefits to the project beneficiaries and/or other constituencies for an extended period after the Commission's financial assistance has been terminated".* Recently, there has been a great emphasis by several organisations to achieve sustainability by incorporating it in the *corporate-level* strategy (Nidumolu, 2016 and Charlesmore, 2008); however, what is included in this word *"sustainability"* is still vague for several organisations. For this research, one of the most appropriate definition of sustainability for a business enterprise is given by the World Commission on Environment and Development that is: *"sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future"*. Overall, this definition is emphasising on two aspects, first-one is mostly done by every enterprise to benefit only them by adopting business strategies and activities, and the second-one emphases to extend this same idea to the world's natural and human resources.

Now the question is that how this can be achieved? And what is its relation with *corporate-level* strategy? As per the above definition, the idea of sustainable development needs to be integrated within organisational planning; and for this, the top management who are the maker of *corporate-level* strategy should be familiar with this. So that they are aware with the importance and can take actions to protect world's human and natural resources in-addition to physical and financial capital of their organisation.

Now lets look at the relationship between *corporate-level* policies and objectives to achieve sustainability. In this regard, it is usually senior management who is responsible for defining sustainable development policies and objectives and expects their employees to follow them (Banerjee, 2002). Here, sustainable development includes all aspects of social, environment and economic (Kolk, 2016) (more details are discussed later in this Chapter). Thus, management should incorporate an organization's mission with respect to sustainable development to be served as a guideline for planning.

Krehmeyer (2010), highlights two main reasons of having a clear and comprehensive sustainability strategy for business leaders, which include (1) knowing and communicating who you are; and (2) knowing where you're going. Here the first

reason imply that it is the responsibility of company executives to communicate and have an overall alignment across all organisation entities on the strategic goals, which is only possible if they will have a clear and comprehensive sustainability strategy. The second reason *"knowing where you're going"* is pointing towards achieving continuous reputation that is critical for long-term viability of an organisation, and for this, business leaders need to incorporate sustainability aspect into corporate-level long-term strategies.

Until this point, it has been concluded that for business leaders, it is important to have a clear and comprehensive sustainability strategy incorporated into organisational corporate-level strategy. Next section go deep into the concept of sustainability, review the state of the art literature in this domain and discuss the link of sustainability with an organisation goals and strategies etc.

2.2 Sustainability

This section reviews the concept of sustainability, sustainability development, role of sustainability in an organization and the need for balancing it as per the environment, social, and economic factors.

Sustainability is to achieve the preservation of asserts for future generations, which humans are currently enjoying (United Nations, 1987). Today, sustainability is becoming one of the most important topics of discussion in organizations especially with respect to management as it affects all kinds of industry or business (Garcez, 2013). This is because including sustainability practices to management have been giving positive results and it is better than traditional approaches (Hart, 2007).

In relation to this research, the definition of sustainability for a business enterprise as outlined by the *World* Commission on Environment and Development is that: "sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future" (Nidumolu, 2013 and Charlesmore, 2008).

As per Epstein (2008), there are various sustainability factors which can be incorporated to management and businesses *e.g. ethics, governance, community involvement, economic development, value of services, employment practices and protection of the environment.* Moreover, these sustainability factors should be considered into routine management decisions in both operation management and investments (Davies, 2008). Accordingly, these findings give us a future direction of the possibility to incorporate sustainability into project portfolio for improved decision-making.

2.2.1 Sustainable Development

A sustainable development is *"a development that meets the needs of the present, without compromising the ability of future generations to meet their own needs"* (Manning et al., 2011). Sustainable development has two parts, one is to make development in a way that used recourses meet human needs; and two, ensure the sustainability of nature and environment to meet the needs of both present and future generations. Such development needs to look at not just climate changes e.g. environment but also various factors in society that includes social and economic (Asif et. al, 2008). Thus, the focus of sustainable development is extended to the preservation a strong, healthy and fair society (such as creating equal opportunity).

Recently the *Leadership Council of the Sustainable Development Solutions Network* (2013) has given more analytical breakdown to the notion of sustainable development by distinguishing it to economic, ecological, political and cultural sustainability. They also referred the other important domains as institutional or as good governance. However, most of the literature, such as (Wang, 2010) and (Hallstedt, 2017), refers sustainable development in three domains i.e. environment sustainability, social sustainability and economic sustainability. Further on the importance of balancing these three environments, social and economic domains of sustainable development are discussed in later sections of this chapter.

2.2.2 Role of Sustainability Policy in an Organisation

Currently, many organisations have established their sustainability policy by making it integral to their mission statement (Asif et. al, 2008). However, for some organisations those are just show-off statements and their management is usually unaware of the actual role of sustainability policy in their organisation. Thus, before building a sustainability policy it is important to know that why an organisation needs it at the first place.

There could be many reasons to build a sustainability policy and one of the main reasons could be that a company was wasteful in the past now they want to go *Green* (Asif et. al, 2008). In this situation, putting together a sustainability policy is good idea to focus on the ways and procedures that help in making that company Greener. Overall, as stated above the role of a sustainable policy is to ensure that company can achieve all their strategic goals, but without compromising the ability of future generations to meet their own needs (Manning et al., 2011). So, a thoughtful and well-documented sustainability policy helps an organisation to meet the up-to-date environmentally related regulations, save money in terms of waste by recycling it, increase supply chain efficiency and improve reputation within stakeholders etc., (Samantha et al., 2011).

All the above-mentioned roles of sustainability policy might not suddenly achievable for an origination. This is mainly because, implementing a sustainability policy could be a continuous process and sometimes it also requires initial (or regular) investments to change the way a business operates (Huemann, 2013). However, these investments are usually not wasted but are returned to the organisation in terms of savings from recycled waste, employees' efficiency, energy savings and more work opportunities with stakeholders.

2.2.3 The Triple Bottom Line - Balancing Sustainability as per Environment, Social and Economic Factors

As per the findings of various researcher e.g. (Broman, 2017), Epstein (2008) and Hart (2007) etc., a sustainable development can benefit to the society in several ways including the social, environmental and economic paybacks. However, managers often do not know how to first come-up with a balanced sustainability policy and then implement that strategy into the organization (Samantha et al., 2011). So, the first thing managers need to know is: *What is balanced sustainability policy?* In literature (e.g. in Broman, 2017; Epstein, 2008; Asif et al., 2008; and Davies, 2008), the concept of sustainability is broad and considerations of all three social, environmental and economic aspects are the fundamental pillars of sustainability (as shown in the following Figure 2.1). Thus, a balanced sustainability policy must accommodate all three social, environmental and economic aspects of sustainability in it.

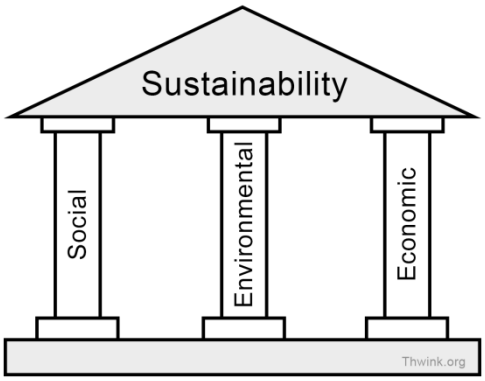


Figure 2.1: The three pillars of Sustainable Development (Sustainability Pillars, 2013) – Social, Environmental, and Economy

Here these three pillars of sustainability are briefed with examples:

a. A ***"sustainable Economic model"*** safeguards fair distribution and efficient allocation of resources. This pillar of sustainability ensures that economic growth maintains a balance with ecosystem (Vardon, 2016). This model is used to define those strategies that stimulate the utilization of socio-economic resources to their finest advantage. Thus, this efficient and responsible use of resources provides long-term benefits and establishes profitability. In short, Economic sustainability does make sure that the business makes profit, but without creating social or environmental issues that would harm the long-term success of that business.

b. In the ***"sustainable Environmental model",*** organisations must preserve natural resources. This is mainly because natural recourses are not unlimited and world must be protected from cooperating misuse and destruction (He and Chen, 2008). A sustainable environmental model supports things like renewable energy, reducing emissions, sustainable agriculture, reducing deforestation, recycling and waste management etc. (Testa et. al., 2016). For example, the rates of waste generation from projects should not exceed the assimilative capacity of the environment, a goal of zero waste, plastic bag reduction, and initiatives to reduce carbon footprint by managing energy consumption, greener packaging, using alternative sources of energy etc.

c. The third pillar of sustainability is Social. A ***"sustainable Social model"*** looks after the well being of people and do not support human inequality, social injustice, and poverty by supporting initiatives like peace and actions that encourage social equity (Thampapillai, 2010). For example, initiatives like food donations, workers' safety, women empowerment, water scarcity, health and wellness of communities around factories etc.

The above-discussed three pillars of sustainability do have their individual importance; however, taking a balanced approach to sustainability has grater advantages and each pillar often supports each other (Samantha et al., 2011). For example, if organisations focus on social and environmental issues, profitability (economic growth) often follows (Thampapillai, 2010). Similarly, Social initiatives or an organisation usually have an impact on consumer behaviour and employee performance (Samantha et al., 2011). Moreover, environmental initiatives such as energy efficiency and lessening pollution can have a straight impact on dropping

waste (He and Chen, 2008). In conclusion, it is every organisation's social responsibility to achieve sustainability by using these three Pillars of Sustainability as per their business operations. The Figure 2.2 shows a common illustration of how these three pillars need to link together to meet the overall goal of sustainability.

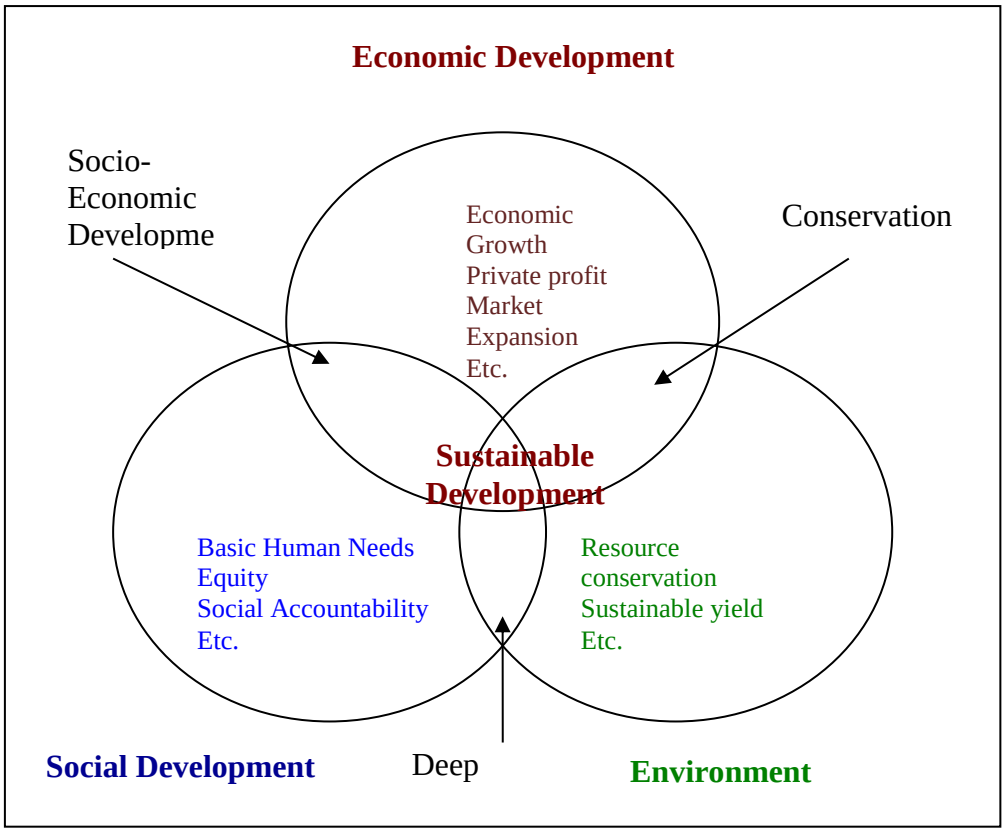


Figure 2.2: The interactions between Environment, Economic and Social development.

Adopted from Bell and Morse (2003)

2.3 Conventional Ways to achieve Green and Sustainable IT

Due to the rapid increase in energy costs and awareness of climate change, Green and Sustainable IT is getting high interest, especially among those organisations who spend huge amount on their IT infrastructures (Jain et al., 2011). Thus, such organisations are looking for business strategies to reduce their environmental impact. Over the years, organisations have adopted several Green IT approaches and innovative solutions to reduce energy consumptions, reduce travel costs and make their procurement practices Green (Edwards, 2008 and Nidumolu, 2016). However, there is no standard definition in the literature for the emerging concept and practices that are usually called "sustainable IT" and "green IT". In relation to this research, the following definition given by the CGI Group in a white report *Emerging Trends in Green IT* (2013) is considered as the closest one: "*Green IT is the study and practice of using computing resources in ways that help reduce energy and operating costs, enable sustainable business practices and reduce the environmental impact of IT practices in the larger community*" (Emerging Trends in Green IT, 2013).

In a recent survey by Info-Tech Green IT Report (2016), sponsored by IBM a detailed investigation on the ways to achieve Green and Sustainable IT adopted by worldwide organisations has been presented. In this survey, more than 1,000 IT professionals, from 12 countries and eight industries were consulted through surveys and interviews to understand why and how Green IT initiatives are undertaken, and how the results translate into cost savings, business value and environmental benefits. The existing literature and the outcomes of Info-Tech Green IT (2016) survey report show that Green and Sustainable IT is being carried out in several areas that include (but not limited to) *virtualisation*, *storage consolidation*, *desktop virtualisation*, *IT energy measurement*, *equipment power management*, *printer consolidation*, *remote conferencing*, *IT equipment recycling*, and *cable waste management* etc. The results show that establishing an organisation-wise centralised storage and telecommuting projects are being undertaken at the wider-scale due to their immediate cost reduction benefits and reduced resource consumption. Moreover, while looking at various Green IT adoption trends, Info-Tech (2016) reports that there are four main areas where *Green IT* and/or *Sustainable IT* is being adopted by the selected organisations that are discussed in the following sub-sections.

a. **Virtualisation Support and Consolidation of Storage Space:** Such approaches and projects are typically adopted to reduce energy cost and improve resource utilisation. In addition to cost benefits, server virtualisation and storage consolidation also gives ease of management. How it works is that virtualisation allows several employees to use one server and have individual interfaces of operating systems running in parallel; similarly, storage consolidation allows the use of virtual storage devices instead of physical devices (Verizon business report, 2013). This arrangement of achieving Green and Sustainable IT provides various benefits such as (a) decrease the devices running in the server room; (b) decrease the space needed to stock these devices; (c) decrease the energy required to run servers/ storage; (d) reduce greenhouse gas emissions; (e) reduce investment on the purchase of servers and storage devices; (f) reduced management time of hardware installations and management as the management is simple when things are centralised on only a few systems (Verizon business report, 2013 and Iyamu and Sehlola, 2012).

b. **Energy Efficiency of IT Equipment:** Many organisations also emphasised on Energy Efficiency to achieve Green and Sustainable IT, which is usually done by server room upgrades, power management, printer consolidation etc. According to Info-Tech Green IT (2016) survey organisations have reported various reasons for constructing new or existing server room upgrades such as to increase effectiveness of cooling and ventilation systems that will result in decreased energy consumption. Over the past few years, organisations' IT infrastructure has also grown into masses; however, most of the organisations still rely on old built small server rooms that are usually inadequately equipped to deal with the heat produced by the housed devices (Jain et al., 2011). Thus, the server room design of past no longer supports IT needs of today and forces unnecessary maintenance and management costs for older facilities.

c. **Reduce Travel by using Remote Conferencing and adopting Telecommuting Strategies:** The Green and Sustainable IT initiatives in this area include promoting remote conferencing and telecommunication facilities to reduce business travel costs. Another reason for reducing travel is that many companies also wish to decrease negative impact on the environment. This Green and Sustainable IT

arrangement usually requires implementation of *video-conferencing* and *teleconferencing* faculties in all offices and client sites of a business (Verizon business report, 2013). Moreover, some organisations also come up with various other initiatives to promote this arrangement such as allowing employees to work from home and encouraging them to work for more hours in a day and only for 4 days a week etc.

d. **Asset Disposal – IT Equipment Recycling:** The adoption of Asset disposal or IT equipment recycling as Green IT initiatives are generally concerned with saving cost, having clean environment and adherence to state regulations (Jain et al., 2011). For most organisations, the single important factor is to decrease IT waste that is usually sent for landfilling or thrown into the sea. Info-Tech Green IT (2016) survey describes that more than 80% of organizations that went for equipment recycling have been successful in achieving their Green IT goals. Moreover, by doing this they also earn good reputation among customers and stakeholders.

The above review on the ways to achieve Green and Sustainable IT does show that there are large companies who have already realised that significant of Green and Sustainable IT initiatives. This does bring various cost savings opportunities by increasing energy efficiency and reducing consumption. Moreover, the initiatives like new server rooms, virtualisation and consolidation techniques also address today's business needs and provide mass energy-saving opportunities (Andrews, 2016). Furthermore, encouraging telecommuting offers advantage of reduced travel, reduced office space and flexible working environment to employees (Iyamu and Sehlola, 2012). The companies who have successfully implemented Green IT initiatives suggest that the success depends on three major factors that require attention i.e.

- Having right and complete support of business stakeholders including top management as its require changes in processes, education of employees and a change in their attitude (Andrews, 2016);
- It is usually the case that companies adopting Green IT initiatives face various obstructions in the approval and implementation due to organisation culture, communication problems, lack of resources etc. (Ismail et al., 2012); and
- The current economic situation of concerning organisation i.e. revenues, Green IT budget or funding, prioritization of projects etc (Edwards, 2008).

2.4 Project Management and Sustainability

The primary challenge of project management is to plan, organize, motivate and control resources to achieve all the project goals (Lawis 2006). During last few years, the concept of sustainability has also been linked with Project Management and this is now also being considered as another challenge for managers among the existing ones of *planning*, *organizing*, *motivating* and *controlling* resources (Gareis et al., 2009). In 2006, the association for Project Management past-chairman Tom Taylor had acknowledged the importance of sustainability and said that *"the planet earth is in a perilous position with a range of fundamental sustainability threats"* and *"Project and programme managers are significantly placed to make contributions to Sustainable Management practices"* (Association for Project Management, 2006). Later in 2008, during the Association for Project Management World Congress, the Vice-President Mary McKinlay stated: *"the further development of the project management profession requires project managers to take responsibility for sustainability"* (Silvius A. J. and Jasper V. D., 2013). Recently, this has also been acknowledged in a survey carried out by Martens and Carvalho (2016) where they

considered key factors of sustainability in project management context. This survey explores the project managers' perspective / challenges to achieve sustainability. Moreover, there has been notable effort by the research community in recognising the importance of incorporating sustainability within project management methodologies and practices. Silvius A. J. and Jasper V. D. (2013), based on their analysis of various projects, reported that it is now inevitable that organisations should bring the application of sustainability principles within project management and it is the responsibility of the overall project management profession that they not only take the responsibility of management of project related activities but also the sustainability aspect of those projects.

Furthermore, there has been notable work done by various researchers, such as on relating sustainable development, project management and sustainability principles (Gareis et al. 2009), sustainable project and technology life cycle (Labuschagne and Brent, 2006), on identifying the challenges of Sustainability (Knoepfel, 2010) etc. This section explores these sustainability aspects related to the Project Management and outlines the existing work carried out in the areas of integrating Sustainability in Project Management Processes and case studies on how existing Project Management Frameworks are linked with Sustainability. Finally, this section outlines the current challenges faced by the research community about integrating Sustainability in Project Management.

2.4.1 The Sustainability Aspects Vs. the Project Management Aspects: How they are Related or Different?

In theory, integrating sustainability aspects to project management stretches the system boundaries, which means that: (1) the complete lifecycle of the project i.e. from *initiation* to *deployment* or *launch* should be considered for sustainability; and (2) also the results the project produces after it got finished should be considered for sustainability, as a project may result in bringing a change in organizational assets, existing systems, behaviour of employees, etc. (Silvius et al., 2009, based on Labuschagne and Brent, 2006).

As per Silvius and Brink (2011) often the requirements of sustainable development and project management are difficult to align together and they do have some major differences in their concepts. For example:

Requirements	Differences Description
	Sustainable Development Vs. Project Management
Short term or long Term	Sustainable development is usually both short-term and long-term, whereas project management is mostly short term, thus the basic idea or relating the project management and sustainable development starts with a conflict;
Target interest	Sustainable development is usually targeted to the interest of current and future generations in terms of social, economic and environmental factors, but in the project management things are mostly planned or executed in the favour of sponsors or stakeholders;
Life Span	Project management is targeted i.e. it is deliverables or results-oriented, but sustainable development is life cycle oriented;
Priorities and	There important considerations of project management are *scope, time* and

preferences	*budget*; however, for sustainable development its *people, planet* and *profit* that come first;
Overall effect	Project management activities ensure that complexities are reduced within the project, but introducing sustainable development sometime increases those complexities.

Thus, above five comparative points show that there is quite a contrast between *concepts of sustainable development and project management.*

2.4.2 Integrating Sustainability in Project Management Process

In recent years, there have been some efforts in integrating sustainability to project management e.g. (Siew, R.Y.J., 2016), (Brook, and Pagnanelli, 2014) and (Gareis et al., 2009) etc. Most of the existing research in this domain is towards understanding the influence (or impact) of integrating sustainable development to the project management processes. Silvius and Brink (2011) have concluded them as "impact areas" and the major ones that have been found relevant to this research include:

- ***Increased project context:*** including sustainability aspect in a project broadens the project context, and now, the project management processes should also cater for the social and organizational context of the project (Siew, R.Y.J., 2016).
- ***Increased number of Stakeholders:*** including sustainability also brings long-terms goals of balancing social, environmental and economic interests; and therefore, this increases the number of stakeholders such as environmental protection and human rights organizations etc. (Heumann, 2009).
- ***Increased project substance:*** including sustainability does demand adopting the project definition, objectives and outcomes as per the sustainability policies; and thus, it may result is adding more demands in terms of project content (He and Chen, 2008).
- ***Project success factors****:* when the principals of sustainability are included in a project then this increase the factors on which a project success is evaluated (Gareis et al., 2009).
- ***Increased Management of Risks:*** Including the demands of sustainability (such as environmental and social aspects) in project management increases the project risks or conditions (Silvius and Brink, 2011).
- ***Employees' development and organizational learning:*** including sustainability also influences the employees' development e.g. in terms of crating equal opportunity etc. which may require implement new practices by the management (Heumann, 2009). Moreover, originations need to learn many things such as recycling, waste management/reduction etc. (He and Chen, 2008).

The above arguments and exploration show that there are several implications of integrating sustainability in projects and project management. Moreover, these implications do not only influence a sub-part of a project or project management, but they are usually related to all *processes*, *methodologies* and *standards* of project management. Thus, it can also affect the competences of the project manager and the ways organizations make strategic plans and administrate their projects.

Silvius and Schipper (2010) also realised sustainability integration into project management processes as one of the most important challenges. In this regard, they have presented a *"Maturity Model for integrating sustainability"* in projects and project management. The proposed maturity model provides practical insights to assess the level of consideration of sustainability in projects, which are as follows: (1) *"Sustainability in projects and project management is about integrating economical, environmental and social aspects in the management and delivery of projects"*; and (2) *"Sustainability in project management stretches the system boundaries of the project and of project management"* (Silvius and Schipper, 2010).

At the 2010's IPMA expert seminar in Zurich entitled *"Survival and Sustainability as Challenges for Project",* one of the major goals was come up with tools for integrating sustainability to the project management. As the first concept, a checklist was developed entitled "Sustainability Checklist" for projects and project managers, which acted as one of the foundations in the development of the maturity model (Silvius et al., 2013). This checklist provides a guideline on integrating economic, environmental and social sustainability to various project management processes; For example, (a) economic sustainability to return on investment and business agility; (b) environmental sustainability to transport, energy, waste, material and resources; and (c) social sustainability to labour practices, human rights and ethical behaviour etc. (Silvius and Schipper, 2010). In conclusion, based on this checklist, the developed maturity model can be used by organizations for integrating sustainability in their projects and project management processes.

2.4.3 How Project Management Frameworks are linked with Sustainability

Recently there has been effort in linking project management frameworks with sustainability and one of the most admired one by the research community is PRiSM (Carboni et al., 2013). In PRiSM, the sustainability aspects are included separately in four different phases of project management i.e. Pre-Project/Initiation (Phase-1), Project Planning (Phase-2), Executing and Controlling the Project (Phase-3), Closing the project (Phase-4).

Here, in the PRiSM "pre-project/initiation" phase (i.e. Phase-1) ideas are formulated and the business reviews are done. These business reviews evaluate on whether this is a feasible project, or evaluate an element of a project to be included within the portfolio of projects that are currently running. At this stage, all measureable elements of sustainability are considered and evaluated as complete package that include: Planet (Environmental aspect), People (Social aspect), Profit (Financial aspect), Process (Governance aspect) and Product (Technical aspect). In the second "planning" phase of PRiSM, which is the actual start of project, the project manager gains an understanding of what the project aims to achieve and identifies the best ways to achieve those goals. At this stage, the sustainability aspects are considered to define quality components and the overall management plans are refined to achieve all goals in the most sensible and safest manner to benefit all stakeholders.

In the third PRiSM's "executing and controlling" phase, planned project activities are performed to accomplish project deliveries. At this stage, no new activity is included to achieve sustainability, but the pre-planned sustainability aspects that were defined at the planning stage are ensured while executing the actual project. Thus, at

this stage processes are used to *monitor*, *measure*, and *control* project performance against the sustainable project plan. The fourth and final phase of PRiSM is the "Closure and Reviews". In a normal scenario, this phase is only concerned with the delivery of planned activities, closure of a project in a structured and organised manner, and carrying out project reviews for accountability and future learning purposes. However, when sustainability is integrated into this phase then the Green matters of the project are included as part of the project review and verified by the concerned officer if the project has achieved the planned sustainability objectives. As per Carboni et al. (2013), some highly mature organisations also hold the sustainability element of the review separately from the normal post project review.

Moreover, according to Silvius et al., (2010), there are a number of principles of sustainability that need to be integrated into project management framework in order to contribute to sustainable development, these include (1) satisfy all three pillars i.e. Social, Environmental and Economic of sustainability; (2) *to achieve* sustainability project management should consider both long-term and long-term consequences of their actions; (3) project management is usually local but after including sustainably organisations should consider effects on economic, social and environmental aspects both locally and globally; (4) organisations need to be more aware that they should not exceed in generating unreasonable environment waste; (5) organisations need to get open and be responsible about the effects on their policies, decisions and action on the environment and how they are going to affect stakeholders (Eskerod and Huemann, 2013); and (6) integrating sustainability into project management also requires consideration of social and ethical issues of the society and not just the accomplishment of project objectives.

2.4.4 Challenges and Discussion on integrating Sustainability in Project Management

While reviewing the requirements, relation and effects of integrating sustainability into project management in above sections; here the outcomes and various challenges to achieve such integration are outlined:

- The project management community needs to understand that they need to do more to contribute to a more sustainable society (Association for Project Management, 2006) and (Benn et al., 2014)
- Integrating sustainability to project management enhances the total life cycle of the project from initiation-development-execution-testing-launch to something like design-develop-manufacture-operate-decommission-disposal (Labuschagne and Brent, 2006)
- Integrating sustainability in projects is not just limited to project management processes, but it must also consider supply chain of the project including the life cycle of the project results and the resources used in realizing those result (Labuschagne and Brent, 2006).
- Today's project management processes and knowledge fall short of committing to a sustainable approach and there is still a lot to be done with regards to the integration of the concepts of sustainability into project management standards (Eskerod and Huemann, 2013).
- The project managers need to take a broad view of their role and to evolve from "doing things right" to "doing the right things right", which means that taking responsibility both the process of delivering a project and for the content and the

results of the project itself including the sustainability aspects of that result (McKinlay, 2008).

In summary, after reviewing the theories and existing work on sustainability and project management, it can be concluded that there are many challenges faced by the research community about integrating sustainability into project management. This is mainly because often the requirements of sustainable development and project management are difficult to align together and they do have some major differences in their concepts i.e. in-terms of short term or long term targets, interests, life spans, priorities, preferences and overall effects. This literature review also shows that there are several implications of integrating sustainability in projects and project management, which do not only influence a sub-part of project management, but they are usually related to all processes, methodologies and standards of project management. Thus, organisations need to be careful while generating sustainability policies as it can affect the proficiencies of the project manager(s) and the traditions how organizations make strategic plans and govern their projects.

Moreover, after reviewing the different phases of PRiSM sustainable project management framework, it can be concluded that in this research, only the "pre-project/initiation" phase is to be considered while integrating sustainability into project portfolio management. This is because, this research is mainly concerned to support "program managers" in evaluating whether an IT project or an element of an IT project is feasible to be included within the Sustainable Portfolio of projects that are currently running in an organisation. Moreover, at this stage all three elements of sustainability i.e. social, environmental and economic also need to be considered. Furthermore, it can also be concluded that the other phases of PRiSM such as planning, executing/controlling, closure and reviews are mainly concerned with the project management and not program management; and thus, they are outside the scope of this research.

2.5 Project Portfolio Management and Project Portfolio Selection

This section introduces the project portfolio management and reviews the existing literature and frameworks in relation to this research.

2.5.1 What are Project Portfolio Management, its Aims and Objectives?

Project Portfolio Management (PPM) provides the capabilities necessary to manage the *time*, *resources*, *skills*, and *budgets* necessary to accomplish all interrelated projects tasks, and it is usually adopted by large big organisations to manage their projects (Michael, 2009). In general, PPM is a complete framework to help management for change and risks management and include five primary activities that include pipeline management, resource management, change control, finance management and risks management (Shan et al., 2007).

For the program managers, one of the key uses of PPM is to decide which projects to fund in an ideal manner. This concept is also known as Project Portfolio Optimization (PPO), which is the effort to formally make the best decisions possible under these conditions (Iamratanakul et al., 2009). In general, for any organization key aims of PPM usually include (a) prioritization of the projects and programs (b) ability to identify problems during planning in order to eliminate surprises; (c) build

contingency plans into overall portfolio to handle potential risks; (d) change management; (e) better recourse exploitation; (f) enhance decisions making and management; (g) improve or build best organisational practices; and (h) the ability to predict or understand organizational needs (Anand, 2007).

2.5.2 Difference between Project Management and Project Portfolio Management

In the above sections a review of project management and how sustainability is linked to project management is presented. Now, as this research is about Project Portfolio Selection and how to include sustainability aspects in it, first there is a need to review some of the basic difference between project management (PM) and project portfolio management (PPM).

Unlike project management that is only concerned with one project, portfolio management is across the enterprise (Heagney, 2016); and therefore, it requires complete organisational perspective to manage different projects across the enterprise. While managing one project, the project managers usually have to deal well-defined scope, timelines, and resources (Heumann, 2009). However, the adoption of portfolio management has no limit and it run for the life of an organisation to analyse and manage various concurrent projects. Thus, the fundamentals of project and portfolio management in terms of managing *scope*, *timelines*, and *resources* are same but in portfolio management these goals are further considered *organization-wide*. It can also be concluded from above discussion that the main objective of portfolio management is to evaluate a project right from the beginning and prioritise existing projects to achieve maximum company strategic objectives.

As per Project Management Institute one of the major benefits of project portfolio management framework is to ensure that all organisational projects are aligned to the business and technological strategy of that organisation (McKinlay, 2008). Moreover, project portfolio management framework provides a common criterion for scoring and monitoring projects throughout an organisation and it ensures that projects are prioritised to achieve maximum benefit. Overall, project portfolio management contributes to meet the both short-term and long-term business strategy and technological goals of an organisation.

2.5.3 Project Portfolio Management and Project Portfolio Selection Literature

Although project management is existent since very long, the history of project portfolio management and selection is not very old. During last few decades project management is being witnessed but it was only recently accepted as a major management discipline (Maylor, 2010). The start of project portfolio management era, as known today, came into existence when originations went bigger and started operating globally. It was during late 1990s when researchers and project managers started to realise the strong need for a way to coordinate the project portfolio (Henriksen and Traynor, 1999), and to set the strategic priorities between various projects and find a balance between those projects (Madic et al., 2011). Those theories were further developed and the first major literature written on portfolio selection topic was a book written by the Nobel Prize winning economist, Harry Markowitz **(**Birgisson, 2012). As per McGrath (2004), in the beginning of project portfolio research, managers also started to ask questions like: How to start a project?

And, how to prioritized them with limited resources? These and other such questions of managing organisational-wide projects further pushed the development and analysis of project portfolio management (McGrath, 2004). Currently, it can be seen that project portfolio management and project portfolio selection is becoming one of the fastest concepts within the field of project management (Madic et al., 2011).

In **(**Birgisson, 2012), a study has been conducted where the scholarly database *science direct* was used to find the number of articles that mentioned "Portfolio Management" in the international *Journal of Project Management* published each year since year 1999. As per the survey results, it is only since 2007 when the PPM research became active. Moreover, recently in 2006, the Project Management Institute has developed and published the first edition of *Standards for Portfolio Management*, and the next one was released in 2008 with changes that were made after reviewing hundreds of recommendations for improvements from various individuals. This shows that Project Portfolio Management (PPM) and Project Portfolio Selection (PPS) is an emerging field and there are still a lot of challenges remaining for the research community. There is still a need to develop PPM and PPS framework along with practical case study that caters for sustainability aspects while selecting an IT project. However, there are some generic PPM and PPS frameworks, methodologies/ approaches and system exist that have been extensively reviewed and a comparison of their features, application domain, benefits and limitations is presented in the next section.

2.5.4 Strategic Frameworks for Sustainable Project Portfolio Selection and Evaluation

In (Khalili-Damghani and Sadi-Nezhad, 2013a) a high-level strategic framework for project portfolio selection and evaluation has been proposed. The presented approach is two-phased. In the first phase it is suggested that planning and selection should be done under strategic objectives; and in the second phase a balance scorecard approach is proposed to assess and evaluate the results of planning and selection phase. Currently, only a high-level framework with abstract information on each component of the framework is provided without any implementations. Moreover, in this work the social, environment and economic factors are not considered from any specific domain. Follow-on to this this work has been reported in (Khalili-Damghani et al., 2013b), where a hybrid fuzzy rule-based multi-criteria framework for sustainable project portfolio selection is presented. According to this work, multiple and conflicting organisational objectives can be used as an input variables in a Fuzzy Rule-Based (FRB) framework to estimate the overall suitability of the potential project portfolios. In order to achieve this, the framework integrates data mining model using both Data Envelope Analysis and Evolutionary Algorithm (EA) to design the structure of the proposed FRB system. The developed rules are based on Meta Heuristics, which are widely used to solve real world problems. In comparison to this research, the focus of this work is on proposing a Fuzzy rule-based multi criteria framework instead of how to integrate sustainability into PPS. Consequently, there is no major overlap of work in terms of examples or case studies. However, the work of Khalili-Damghani et al., (2013a) (2013b) confirm that future work is needed to investigate the applicability of the proposed approach to business and engineering domains such as IT projects selection.

Another related framework entitled "an integrated framework for project portfolio selection" has been investigated by (Archer and Ghasemzadeh, 1999). The proposed

project portfolio selection framework separates the project selection into various stages with objectives and details. Here, each identified stage accomplishes a particular objective and creates inputs to the next stage. The framework theoretical and it is claimed to be extendable and the users are free to choose the techniques they suitable for each stage. Overall, the work of (Archer and Ghasemzadeh, 1999) provides various guidelines to build a decision support system for project portfolio selection. In terms of limitations, the proposed framework is abstract and only outlines various stages that may occur in a project portfolio selection process. Moreover, no details on the staged components or specific implementation are provided and the uses need to choose their own suitable implementation technique for each stage, or in some cases to omit or modify a stage if needed. However, the work of Archer and Ghasemzadeh (1999) also confirms the need to investigate generic requirements for decision support in project portfolio selection, including modelling techniques and data gathering from existing projects.

In (Strang, 2011), a case study development has been reported that examines mixed-method action research approach to evaluate project proposals. In the case study, first portfolio selection and evaluation theories are explained through the project management and business disciplines. Further, mixed-method variations and examples are reviewed followed by the proposal of an improved project selection and evaluation methodology. The population of this case study was massive i.e. consisting of over 700 project stakeholders, including experts and decision makers, in the program evaluation committee. Moreover, there were over 5,000 criteria identified for bidders to respond to, comprising both qualitative and quantitative data types, and additional qualitative indicators. The major focused of this case study remained towards conducting an investigation into mixed-method i.e. integrated qualitative and quantitative portfolio selection model, to evaluate complex, publicly sensitive project proposals. The outcomes show that how a mixed-method is useful to evaluate projects when scientists, subject matter experts, politicians, and citizens often differ on scope, budget, time, and quality priorities. The outcomes of this case study also suggest that it is dangerous to apply either a qualitative or exclusively quantitative method when evaluating publicly sensitive nuclear-related projects, because taking one or the other portfolio selection approach can lead to oversight, safety problems, budget overruns, and/or outright failure. This was a very interesting finding and in this research a mixed method consisting of both qualitative and quantitative parameters to evaluate project proposals is used. In terms of limitations, although this work presents an improved project selection and evaluation methodology based on the mixed-method action research approaches, none of the sustainability aspect was considered during selection of projects. In terms of evaluation or practical application, the original case study seems to be very big, but only a small subset is published in the papers due to privacy issues. Overall, the major difference with this work is that the proposed project portfolio selection model doesn't cater for sustainability aspects.

2.5.5 Application of Multi-criteria Decision Analysis in Design of a Sustainable System's Framework

The recent work of Nasrin and Duecker (2013) presents a framework on Strategic positioning by design of a sustainable environmental management system (SEMS). The major benefit of this proposed model in that it provides a strategic positioning of pollution prevention and clean production projects via design of a SEMS. Nasrin and Duecker (2013) have reviewed various multi-criteria decision making models and the

ELECTRE III multi-criteria decision-making model was selected as an integral part of the framework due to its ease of application. Overall, the proposed SEMS framework can be used to meet sustainability goals and objectives of organizations pursuing waste minimization, process optimization, or improvements in process efficiency and energy use. In comparison to this work, the proposed SEMS framework is mainly providing guidelines for organizations pursuing waste minimization, process optimization, or improvements in energy use. But, it is not considering how these (or other) sustainability factors can be incorporated into PPS or PPM frameworks.

Gome de and de Barros (2014) presented an approach to solve project portfolio selection problem in the presence of *"limited resources, multiples criteria, software projects, constraints, functions to be optimized, interdependent projects, and scenarios with a large number of projects available".* In this study a vast amount of data were collected from a set of 42 software projects originated from strategic planning of a midsize company. The approach works in two phases i.e. (1) in the first phase – portfolio optimization is performed using the multiobjective algorithm such as NSGA-II etc. (Gome de and de Barros, 2014) (ii) in the second phase - post-optimization of portfolio is performed using the Analytic Hierarchy Process (AHP). This work presents a conceptual model (supported by literature) considering aspects of multi-objective project selection AHP without going into the detailed PPS criteria specifications. Another major different with this work in that the proposed approach doesn't consider any aspect of sustainability integration while considering about strategic orientation or project portfolio selection. Overall, the approach of Gome de and de Barros (2014) does encourages and guides decision-making based on AHP, but cannot be used as the sole method for project portfolio selection.

The SEMS framework identifies that a visible and on-going involvement of the organization's leadership as well as internal and external stake-holders in the development of environmental sustainability policies; however no guidelines are provided on how these can be practically integrated into a project portfolio selection framework. In summary, the main focus of Nasrin and Duecker (2013) work is on identifying and evaluating steps involved with SEMS design and not the integration of sustainability to a project portfolio selection framework as investigated in this thesis.

Another multi-stage decision framework of R&D project portfolio selection is presented in (Abbassi et. al., 2013) including a balanced set of R&D project evaluation criteria i.e. a 0–1 nonlinear mathematical programming method for balancing portfolios and risks. Abbassi et. al. (2013) also briefly includes various sustainability measures but not specifically address any area of sustainability. The key benefit of the approach is that it can be used to consider project interdependencies types and other constraints while R&D project portfolio selection. The proposed multi-stage decision framework captures the dynamic interrelation between different projects by considering their values and risks. Overall, the novelty of this approach is the proposed evaluation framework considering portfolio values and risks, projects' interdependencies and separation between various research project categories. It works in four major modules i.e. (1) research projects categorization; (2) identifying research projects evaluation criteria; (3) constructing mathematical model; and (4) research projects evaluation and constructing R&D project portfolio. Moreover, the authors nicely describe 20 measures for assessing project portfolio values and use them to calculate average scores and standard deviations of the initial list of measures.

However, such measures are not applicable or fully catering for measuring sustainability as considered in this thesis.

2.5.6 Project Portfolio Management, Strategic Alignment and Sustainability

In (Heising, 2012) a detailed conceptualization of relationship between ideation (front end success) portfolio management and project portfolio management is presented. Here, the author addresses the conceptualization of how ideation can facilitate and sustainably improve portfolio success in the product development environment in the long-term. The Major focus of this work is on how the project ideas can be further developed to improve portfolio success for new product development. However, no specific sustainability issues (i.e. economic, social or environment) have been considered. The proposed conceptual framework is based on existing literature and interview questions and not by applying to a specific domain. The future work identified conforms to the research done in this thesis, which suggested the application of the proposed conceptual framework on real scenarios and evaluating the results; and also, to come up with scales for evaluating portfolio success.

A project portfolio approach to urban sustainability management is proposed in (Andersson and Lyden, 2006). This proposed project portfolio approach aims at facilitating cross-sectorial co-operation between departments of the city administration. In this approach, cluster analysis technique is used to help identify projects form groups when setting priorities for urban sustainability. The proposed project portfolio approach can be used to show that sustainable solutions may generate economic benefits. The approach itself is a phased approach to create and manage a project portfolio in the urban planning/construction industry. The approach is not applied or tested on any other domain and focused only towards city administration. The overall theoretical framework and conclusions are based on previous project experience on how to use a phased approach to create and manage a project portfolio in the urban planning.

Blichfeldt and Eskerod (2008), conducted 128 in-depth interviews in 30 companies, and proposed that a key reason why companies do not do well in relation to project portfolio management (PPM) is that PPM often only covers a subset of on-going projects, while projects that are not subject to PPM tie up resources that initially were dedicated to PPM projects. The suggested that there is need to include all projects in PPM, and aiming at keeping the resource and cognitive burden of doing PPM at a reasonable level. Overall, the outcomes of Blichfeldt and Eskerod (2008) work identified three main problems in relation to PPM i.e. (1) projects are not completed according to plan; (2) management and employees feel they lack a broad overview of on-going projects; and (3) people experience stress as resources are continuously reallocated across projects in order to make ends meet. Due to the exploratory nature of the study accounted for in this work, the presented findings relate far more to what companies actually do, rather than to what they ought to do. Thus, authors suggest a future work that, “the key challenges for PPM theory in the future are to produce normative theory that offers sound suggestions as to how companies can improve their PPM”. Moreover, this work has been useful to build initial ideas about the work conducted in this thesis especially the suggestions as to how companies can improve their PPM. However, there is no sustainable project portfolio selection framework or criteria are proposed.

Antonio and Madalena (2009) developed a technique for the project alignment with the organisational strategy, in order to select projects that later on can be considered in the analysis and selection of the portfolio. The proposed methodology for assessing the project alignment index can assist organisations to gain an awareness of market dynamics and speed up the decision process to improvement of the organisational performance. According to authors, the current state of practice, in large organisations, shows it is very hard to accomplish a significant success in the portfolio selection and management of individual projects as well as programme management practices. According to the authors' view, based by the literature review, the project portfolio selection (PPS) normally, involves five distinctive phases that include *strategic consideration, project evaluation, portfolio selection, resources assignment,* and the *monitoring and control* phase. In relation to this research, there isn't any direct overlap as the main contribution of Antonio and Madalena (2009) work is mainly towards the project alignment index calculation phase. This phase intends to quantify the data collected from various indicators, and then determines an index for each project in the evaluation process. The overall technique is divided in three main steps, which are: 1) set the minimum values of attractiveness by indicator; 2) calculate the indicators score by project; and finally 3) sort the different projects in study for portfolio section. However, the approach isn't applied on any real world scenarios not any integration of sustainability issues in the PPS process has been considered. Overall, this work gives a general idea about the concept of project portfolio management, from its multidisciplinary nature. Moreover, passing through various literatures it highlights the different techniques, models and tools used to solve the multiple PPM problems.

Meskendahl (2010) examined the linkage between business strategy, project portfolio management, and business success to close the gap between strategy formulation and implementation. Based on a literature review, Meskendahl (2010) proposed a conceptual model considering strategic orientation, project portfolio structuring, project portfolio success, and business success. Although the model presented is quite abstract but the model's design is claimed to be not limited to a specific project type or industry and consequently allows the broad application to various project portfolio. In summary, the proposed conceptual model expands existing theories in project portfolio management and theoretically contributes to establish a link between strategy formulation and strategy implementation. However, contextual project factors are also not considered in the proposed model and further empirical research is also needed to see if this model can be practically used on the influence of strategy on project portfolio management and its success. Thus, this research is quite different to ours as Meskendahl (2010) did not explored the integration of sustainability while considering about strategic orientation, project portfolio structuring etc.

2.5.7 Analysis, Ranking and Selection of R&D Projects in a Portfolio

Recently Gutierrez, and Magnuss (2014) carried out an interview study of three industrial companies two explore how different decision-making approaches are combined in a project portfolio management / decision making. The analysis results of this study show that rational and formal decision-making processes are experienced as more legitimate than informal and non-rational ones. Overall, 30 interviews were conducted in three companies; i.e. 10 interviews in each company, and two researchers were present at each interview. In terms of major outcome, a survey was

conducted on existing approaches with the outcome that rational and formal decision-making processes are experienced as more legitimate than informal and non-rational ones. The research approach chosen for this study is an exploratory and qualitative study with data collected via semi-structured interviews. This chosen method for investigation is claimed to be appropriate for understanding organisational and social phenomena and, in particular, decision-making processes. In relation to the research presented in this thesis, this work doesn't attempt to propose a project portfolio framework that caters for sustainability aspects.

A review on recent empirical research literature regarding project portfolio selection and management is presented in (Martinsuo, 2013), which draws attention to the limitations with viewing portfolio management as a rational decision process. The work of Martinsuo, (2013) aims to develop new avenues for research regarding project portfolio management in practice and in context. It highlights that in order to respond to uncertainties and complexities in business environments, project portfolio management can be viewed as negotiation and bargaining and as structural reconfiguration, besides rational decision processes. In terms of limitation with respect to this thesis research, this work is conceptual in nature; and therefore, no new empirical evidence is reported. However, prior empirical research is broadly covered, and particular attention is paid to suggesting avenues for further research based on the review. This paper assumes that any types of projects may be included in project portfolios; and therefore, the problems identified and recommendations are generic and high level. Moreover, in the sustainability is also not considered by the author.

A method for the analysis, ranking and selection of R&D projects from a portfolio is presented in (Linton, Walsh and Morabito, 2002). Linton, Walsh and Morabito (2002), proposed that an objective multi-criteria decision making method, named as Data Envelopment Analysis (DEA) can be used to split a portfolio of projects into accept, consider further and reject sub-groups. One of the major benefits of the approach is that the proposed method can be used for the analysis, ranking and selection R&D projects in a portfolio. Moreover in their approach, the combined use of objective (DEA) and subjective visual support tool like the Value Creation Model (VCM) methods offers the advantages of both techniques, while minimizing their disadvantages. In terms of limitations, this analysis does not consider interdependence of multiple projects in a portfolio. Moreover, with respect to this research, the measures used for the analysis of R&D projects by the are mainly cash flow, investment and product market and other measures or sustainability related factors are not considered. Moreover, their proposed project portfolio selection method does not cater for sustainability integration at all.

2.5.8 Project Portfolio Selection in Continuous Improvement

Bernard and Sami (2011) present a systematic overview of approaches to project portfolio selection in continuous improvement and to identify opportunities for future research. Primarily in this work, the authors provide a review on the theory/application of project portfolio selection in continuous improvement and identify three gaps in the current state of the art: (1) optimisation of the future state of portfolios; (2) adequate portfolio generation; and (3) the appropriate measurement to judge outcomes. The review presented in this paper is quite useful in terms of filling some gap in the literature by providing overview of project portfolio selection approaches, an understanding of the shortcomings of current approaches and a normative model that highlights areas for further research. In relation to this research,

a comparison of Multiple Attribute Decision Making (MADM) and focussing on objectives i.e. Multiple Objective Decision Making (MODM) is also presented in this work. The major difference between MADM and MODM is that the MADM begins with a finite set of explicitly defined alternatives and attempts to maximise the portfolio outcomes, and MODM explicitly defines objectives and sets out to select from an infinite set of alternatives. This was catered to go with a finite set of explicitly defined alternatives in a portfolio. In terms of limitation with respect to this work is that this work mainly examines the literature on portfolio and project selection in continuous improvement and presents a descriptive framework that represents the current state. Moreover, it has been concluded in this paper that there are significant limitations to the approaches used by industry for project selection and the methods described in the literature do not offer an adequate solution to this problem too. Furthermore, the benefits and shortcomings of the project portfolio selection methods are recognise by the authors in order to assist them in with various choices, but not a complete design of PPS framework has been proposed.

2.5.9 Project Portfolio Selection Model: Uncertainty, Fuzzy Theory or Metaheuristic-based Approaches

Pourahmadi, Nouri, and Yaghoubi (2015) presented a scenario based mathematical model for project portfolio selection, which can be used when project parameters are under uncertainty. The preliminary results of their work indicate that profitability can be increased by considering different scenarios instead of one single scenario. Their approach considers the project portfolio selection problem into two objective functions, where the first one maximizes the net present value while the second objective function is the minimization of the positive deviations from the allocation of resources. In relation to this approach, this approach does not propose an end to end project portfolio selection framework or considers sustainability factors while selecting projects.

Urli and Terrien (2010) proposed a project portfolio selection approach based on the generation of efficient portfolios by the metaheuristic and on an ‘objective’ analysis of these portfolios. This approach is used to make good recommendation to the portfolio committee or the decision makers. This approach shows how an existing PPS model, such as presented by Archer and Ghasemzadeh (1999), may be adapted to real situations. Overall, the presented approach is more than a decision approach in the sense that they propose a subset of the best efficient portfolios to the portfolio committee. On of the key merits of this approach is that it does not require the decision maker’s preferences because the determination of this subset relies on two general concepts: the performance and the centrality of portfolio. In relation to this research, the work of Urli and Terrien (2010) mainly focuses on how an existing PPS model, such as presented by Archer and Ghasemzadeh (1999), may be adapted to real situations generally characterized by interdependencies between projects. Moreover, the proposed approach does not cater for continuous portfolio improvement. This is suggested by some authors (e.g. Bernard and Sami (2011)) the real-life project portfolio problems are concerned with adjusting an existing portfolio and evaluating the attractiveness of an individual project (alternatives) with respect to the on-going projects, instead of choosing a subset of proposals from the first. Moreover, in contrast with this research, Urli and Terrien (2010) do not attempt to propose a project portfolio selection framework that can cater for sustainability aspects.

Over the past few years, there has been quite an effort on the development of a fuzzy R&D portfolio selection model to hedge against the R&D uncertainty. In this regard, Wang and Hwang (2007) proposed a R&D portfolio selection approach where fuzzy set theory is applied to model uncertain and flexible project information. Their proposed approach aims to simplify R&D portfolio decision making when market and technology dynamics lead to unavailable and unreliable collected data for portfolio management. In this approach, the R&D portfolio selection problem is formulated as a fuzzy zero–one integer programming model that can handle both uncertain and flexible parameters to determine the optimal project portfolio. The benefit is that the proposed approach can assist decision makers in selecting suitable R&D portfolios, while there is a lack of reliable project information. These conclusions made by authors are largely based on theoretical evaluations and a detailed empirical work is further required to ensure the practical applicability of the proposed method(s).

2.5.10 Project Portfolio Selection Using Multi-stage or Interactive Approaches

Da Silva et al. (2016) proposed a 2-step interactive approach for project portfolio selection. The approach uses two coordinated charts: (1) an interactive project timeline with drag-and-drop functionalities for project reallocation in time; and (2) an interactive cost and risk chart that combines a line chart and several bar charts in order to present multidimensional time-based datasets. These interactive functionalities provided via these chats enable project managers refine the PPS model using software (Da Silva et al., 2016). In comparison to this approach, this approach does not consider sustainability factors in project portfolio selection.

Another project portfolio selection methodology based on interactive approach is presented in (Nowak, 2013). The work of Nowak (2013) first highlights requirements for decision support techniques dedicated to project portfolio selection problems and then propose to use dynamic programming for identifying the best solution with respect to each criterion. Nowak (2013) argues that an interactive approach can be generically be applicable to all areas of sustainability but the author doesn't provide any specific practical case studies. One of the key merits of this approach is that the decision-maker is involved until the end of portfolio selection process. Whereas the other existing approaches assume that the information about the decision-maker's preferences is collected before starting the calculation procedure and the calculation can be done without decision-makers involvement. The approach works in a way of quasi-hierarchical approach to find a proposal (from a set of proposals) for the decision maker and then decision-maker evaluates the proposal or makes suggestions. Authors claim that this can help decision-makers to look into multi-criteria while selecting a project. The key difference of this approach with ours is that this approach presents a portfolio selection methodology by assuming that a single portfolio is proposed to the decision maker in each iteration. Based on this the decision maker evaluates the proposal step-by-step. However, in this case all of the proposals are presented at once to the decision makes (including the on-going projects) for evaluation. Moreover, Nowak (2013) work doesn't entirely aim to propose a new universal method for project portfolio selection, but only to formulate an idea within which such a procedure could be designed. Thus, no new PPS framework is proposed which caters for sustainability aspects and that is the major difference with this research.

In (Benaija, K. and Kjiri, L., 2015) a method of projects selection is described as part of the projects portfolio management, which uses an interactive approach due to the involvement of decision makers throughout the decision making process. The proposed interactive approach works in two steps i.e. (1) in the first step, a classification of projects based on the three most important criteria namely the *"value maximization, risk minimization and strategic alignment"* is carried out; and the second step is about building alternatives portfolio by the portfolio managers taking into account the classification of projects already completed in the first step (Benaija, K. and Kjiri, L., 2015). In this approach no attempt has been made to define a new project portfolio selection framework. Moreover, the approach itself is very useful but it does not analyse all the possible portfolio alternatives, and it is focused on further analysing the pre-classified alternatives selected by the managers. In relation to this approach, this approach also does not consider sustainability.

2.5.11 Diagraming Goals and Dominance-Based Rough Set Approaches for Project Portfolio Selection

In (Zaras et al, 2012), a *"Dominance-based Rough Set Approach (DRSA)"* approach for the decision support is proposed to select the projects that are proposed by the contractors and partners. Originally, this *DRSA* approach was built to assist the Board of Directors of the Community Futures Development Corporations (CFDC), to select the projects that are proposed by its contractors and partners. In terms of assistance in decision-making, the approach considers a balanced set of 22 indicators is that derive from five perspectives: economic, social, demographic, health and wellness. Thus, it is useful for program managers for decision support to evaluate and select projects. However, the main contribution of their work is towards the use of rough set theory to simplify the process of selecting a portfolio for sustainable development. It is proposed that reducing a number of redundant indicators and identifying the critical values of selected indicators can achieve this. The main difference of this approach with this work is that the applicability of such an approach in other sectors/domains is not tested. The presented approach and case study uses pre-calculated classification values. In the case of example case study, the database of CFDC was used to classify municipalities into four categories based on economic, social, demographic, health and well-being with the help of a multi-criteria method and the active participation of experts and managers. However, such is approach is not practical (or applicable) especially for IT projects portfolio where straightforward preparation such numerical classifications is not possible.

Martinez, Joshi and Lambert (2011) propose the use of decision-aiding diagrams of top- level goals and resources to aid in project portfolio selection. The major aim of this work is to refine and choose among the optimization-generated portfolios of projects through path diagram of resources and system goals. Overall, the authors have explored a relationship between the resource allocation and the system goals to complement the traditional decision-making process. In terms of benefits, the developed methodology can assist to the generation of project portfolio management solutions by developing path diagrams to relate resources to goals. In contrast to the research presented in this thesis, the major contribution of Martinez, Joshi and Lambert (2011) work is path diagrams that are developed to relate resources to goals. This has been proposed in order to guide the decision-maker to evaluate if individual portfolios are consistent in allocation of resources and the top-level goals of the system. Another, identified limitation of this research is that only a project's positive

contribution to system goals is considered while generating path diagrams. Thus the proposed approach does not cater for variable goals (for instance, lowering safety standards). Such goals or sustainability contributions of projects are not considered in this research. Moreover, the effectiveness of the proposed approach is not considered for the cases where two projects have the same impact on a goal, but if one has a higher capital cost than the other. In this case path diagram may support the one with less cost. Furthermore, in contrast with this research, no effort has been made towards building a sustainable project portfolio selection framework.

2.6 Comparison Table of existing PPM and PPS frameworks

All the above-discussed related systems / approaches / frameworks have been further reviewed and a detailed comparison is provided in terms of their features, application domain, benefits etc. In this regard, first an outline of the comparison attributes/properties is presented as follows:

S. No.	Comparison Attribute/Properties	Description
1	*Research title*	The title of research work / paper
2	*Reference*	Citation of the paper, and full reference is provided in the *References* section
3	*Major Contribution*	Major contributions in terms of framework development, decision support system development, application software, methodological approach or criteria/index development
4	*Area of Sustainability*	If the work is specific to one or more areas of sustainability *i.e. Social, economic or environment*
5	*Research Span/Duration*	Duration or Span or research / case studies considered
6	*Specific to any application domain/field*	If this research is related to domain/field or industry e.g. construction, electronics, medical, engineering projects or IT projects
7	*Features/ Benefits*	What are the precise features under major contribution as listed above in (3) and/or list of major benefits of using this approach/framework/methodology
8	*Consideration of IT projects portfolio*	Is the approach straight-away applicable for IT project selection
9	*Practical Evidence*	Is the approach is practically tested on one or more scenarios
10	*Method proposed for sustainability integration to PPM/PPS*	Is the research providing any precise and strong theoretical foundations on integrating sustainability to PPS framework
11	*Evaluation Results*	Is an evaluation is carried out to see the practical viability of proposed method/approach
12	*Limitations with respect to this research*	List all identified limitations in relation to this research

Comparison Table of related PPS Approaches / Frameworks / Models

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
1	*A Visualization-Based Approach for Project Portfolio Selection*												
	(Da Silva et al., 2016) *New Advances in Information Systems and Technologies*	**Area:** PPS Proposed an interactive approach for solving a project portfolio selection problem.	NA	NA	No	The use of interactive charts enables users to refine a PPS model.	No	Yes	NA	Yes	No	Yes	The approach uses two coordinated charts: an interactive project timeline and an interactive cost and risk chart in order to present multidimensional time-based datasets. In comparison to this approach, this approach does not consider sustainability factors in project portfolio selection.
2	*A scenario based project portfolio selection*												
	(Pourahmadi, K., Nouri, S. and Yaghoubi, S., 2015) *Management Science Letters*	**Area:** PPS Presents a scenario based mathematical model for project portfolio selection when parameters are under uncertainty.	NA	NA	No	The problem considers two objective functions where the first one maximizes the net present value while the second objective function is the minimization of the positive deviations from the allocation of resources.	No	No	NA	No	No	Yes	The preliminary results of this work indicate that profitability may be increased by considering different scenarios instead of one single scenario. This approach does not propose a PPS framework or considering sustainability factors in selecting projects.
3	*Project portfolio selection: Multi-criteria analysis and interactions between projects*												
	(Benaija, K. and Kjiri, L., 2015)	**Area:** PPS A project selection approach based on the	NA	NA	NA	The approach proposes to study projects based on the three criteria namely the value maximization, risk minimization and	No	Yes	General	No	No	Yes	No PPS framework has been define and also the approach does not consider any sustainability aspects. Moreover, the approach does

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	arXiv	intervention of decision makers throughout the process.				strategic alignment is carried out.							not analyse all the possible portfolio alternatives, but it is focused on further analysing the pre-classified alternatives selected by the managers.
4	*Strategic framework for sustainable project portfolio selection and evaluation*												
	(Khalili-Damghani and Sadi-Nezhad, 2013a) International journal of sustainable strategic management	**Area:** PPS Proposed a high-level strategic framework for project portfolio selection and evaluation	NA	Unknown	No	A two-phased approach is proposed, in the first phase it is suggested that *planning* and *selection* should be done under strategic objectives; and in the second phase a balance scorecard approach is proposed to assess and evaluate the results of *planning* and *selection* phase.	No	No	NA	No	No	No	A high-level framework with abstract information on each component of the framework. The social, environment and economic factors are not considered and the framework is not applied or can be applied to a specific domain; and thus, may require modification, customisation and extensions.
5	*A hybrid fuzzy rule-based multi-criteria framework for sustainable project portfolio selection*												
	(Khalili-Damghani et al., 2013b) Information Science Journal	**Area:** PPS Fuzzy rule-based multi criteria framework for PPS	NA	NA	No	The multiple and conflicting organisational objectives can be used as an input variables in a Fuzzy Rule-Based (FRB) Framework to estimate the overall suitability of the potential project portfolios.	No	No (Not for PPS, but Yes for specifying rules within the hybrid approach)	NA	No	No	Yes	Major focus of the paper is on proposing a Fuzzy rule-based multi criteria framework instead of how to integrate sustainability into PPM/PPS. Extension to (Khalili-Damghani and Sadi-Nezhad, 2013), but towards the direction of using Fuzzy rule-based multi criteria for PPS with no case studies.
6	*Application of multi-criteria decision analysis in design of sustainable environmental management system framework*												
	(Nasrin and Duecker, 2013) Journal of	**Area:** Sustainability Framework on Strategic positioning by	Environment	Consider one Project	*No*	Provides a strategic positioning of pollution prevention and clean production projects via design of a a sustainable environmental	No	Yes Modelled based on an actual industry	Business	No	No	Yes	Mainly providing guidelines for organizations pursuing waste minimization, process optimization, or improvements in energy use. But, it is not considering how these (or

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	Cleaner Production – Elsevier	design of a sustainable environmental management system.				management system (SEMS).		of energy drinks and bars)					other) sustainability factors can be incorporated into PPS or PPM frameworks.
7	*A multicriteria approach to project portfolio selection: Using multiobjective optimization and Analytic Hierarchy Process*												
	(Gomede and de Barros, 2014) In *Information Systems and Technologies*	**Area:** PPS It presents an approach to Solve project portfolio selection problem in the presence of limited resources and using multiples criteria.	NA	The data used in Experiments data include 42 software projects from a midsize company.	No	The proposed project portfolio selection Problem is divided it into two phases, one for (i) optimization using the multiobjective algorithm (ii) post- optimization using the Analytic Hierarchy Process (AHP).	Limitd	Yes	Software Projects	No	No	Yes	The approach of this work encourages and guides decision-making based on AHP, but cannot be used as the sole method for project portfolio selection. The work doesn't consider any aspect of integrating sustainability while considering about strategic orientation or project portfolio selection etc.
8	*The integration of ideation and project portfolio management — A key factor for sustainable success*												
	(Heising, 2012) International Journal of Project Management – Elsevier	**Area:** PPM Framework for the conceptualization of relationship between ideation portfolio management and project portfolio management	NA	NA	No	Conceptualization of how ideation can facilitate and sustainably improve portfolio success in the product development environment in the long-term	No	No	NA	No	No	No	The major focus is on how the project ideas can be further developed to improve portfolio success for new product development. However, no specific sustainability issues *(i.e. economic, social or environment)* have been considered.
9	*The Project portfolio Approach to Urban Sustainability Management*												

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	(Andersson and Lyden, 2006) Material for the Sustainment workshop	**Area:** PPM/PPS Development of a Project Portfolio Approach	Economic	Unknown, but mainly considered urban planning/ construction industry	Urban planning /construction industry.	Facilitating cross-sectorial co-operation between departments of the city administration. In this approach cluster analysis technique is used to help identify how projects form groups when setting priorities for urban sustainability.	No	No	Urban City Planning	No	No	No	The approach is not applicable or tested on any other domain and focused only towards city administration.
10	*An integrated framework for project portfolio selection*												
	(Archer and Ghasemzadeh 1999) International Journal of Project Management – Elsevier	**Area:** PPS Project Portfolio Selection Framework which separates the work into distinct stages	NA	NA	No	Guidelines are provided to build a decision support system for project portfolio selection.	No	No	NA	No	No	No	The proposed Framework is outlines various stages that may occur in a project portfolio selection process. No details on the staged components or specific implementation details are provided. Uses need to choose their own suitable implementation technique for each stage. The proposed PPS framework does not cater for sustainability integration.
11	*Analysis, ranking and selection of R&D projects in a portfolio*												
	Linton, Walsh and Morabito, 2002) R&D Management - Wiley Online Library	**Area:** PPS A method for the analysis, ranking and selection of R&D projects from a portfolio.	NA	Application of the proposed method to the research portfolio of projects from Bell Laboratories'	No	The combined use of objective (DEA) and subjective visual support tool like the Value Creation Model (VCM) methods offers the advantages of both techniques, while minimizing their disadvantages.	Yes	The relation between research strategy and consideration of categorical data is considered.	NA Various Projects from Bell Laboratories'	No Used existing method to graphically display project value	No	Yes	This analysis does not consider interdependence of multiple projects in a portfolio Measures used for the analysis of R&D projects. Sustainability related factors are also not considered.

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
12	*Dealing with legitimacy: A key challenge for Project Portfolio Management decision makers*												
	(Gutierrez, and Magnuss, 2014) International Journal of Project Management	**Area:** PPM/PPS An explorative study on decision situations in PPM.	NA	Interview of three industrial companies	No	The chosen method for investigation is claimed to be appropriate for understanding organisational and social phenomena and decision-making processes.	NA	No	Industries, including aerospace and electronics	No	No	Empirical investigation via Interviews	This paper mainly explores how decision makers combine different formal and rational decision-making approaches when facing different decision situations in PPM.Overall, it is based on an explorative study with interviews to people involved in the evaluation, selection and prioritization of ideas and projects.
13	*Portfolio Selection Methodology for a Nuclear Project*												
	(Strang, 2011) Project Management Journal - Project Management Institute	**Area:** PPS A Case Study development that examines mixed-method action research approach to evaluate project proposals.	NA	Over 700 project stakeholders,	Nuclear project of tritium extraction facility	An investigation into mixed-method i.e. integrated qualitative and quantitative portfolio selection model, to evaluate complex, publicly sensitive project proposals.	No	Yes	Applied to a tritium extraction facility for the evaluation of nuclear project proposals.	Limited	No	Yes	None of the sustainability aspect was considered. Although the original case study claimed to be very big, only a small subset is presented in the paper due to privacy issues.
14	*Project portfolio selection in continuous improvement*												
	(Bernard and Sami, 2011) International Journal of Operations &	**Area:** PPS A systematic overview of approaches to project portfolio selection in continuous	NA	NA	No	The review presented in this paper fills some gap in the literature by providing overview of project portfolio selection approaches, an understanding of the shortcomings of current	No	NA	NA	NA	No	NA	In this paper the benefits and shortcomings of the project portfolio selection methods are recognise to assist them in with various choices, but not a complete design of PPS framework is proposed.

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	Production Management	improvement and to identify opportunities for future research.				approaches and a normative model that highlights areas for further research.							
15	*Project portfolio selection model, a realistic approach. International Transactions in Operational Research*												
	(Urli and Terrien, 2010) International Transactions in Operational Research	**Area:** PPS Generation of efficient portfolios by the metaheuristic and on an 'objective' analysis	Social and economic	Based on an existing example of 15 project's data	No	Authors propose to opt for a decision aid approach; that is more than a decision approach in the sense that they propose a subset of the best efficient portfolios to the portfolio committee.	No	Based on existing literature	NA	No	No	No	The paper mainly focuses on how an existing PPS model, such as presented by Archer and Ghasemzadeh (1999), may be adapted to real situations generally characterized by interdependencies between projects. However, no PPS framework is proposed which caters for sustainability aspects.
16	*Project Portfolio Selection Using Interactive Approach*												
	(Nowak, 2013) Elsevier Procedia Engineering Journal	**Area:** PPS A project portfolio selection methodology based on interactive approach.	Generic approach applicable to all areas of sustainability. But no specific case studies presented.	Example (but self created) data considered for 6 companies to explain the approach via a brief example.	No	In this approach the decision-maker is involved until the end of portfolio selection process. The other existing approaches assume that all the information about the decision-maker's preferences is collected before starting the calculation procedure.	No	No	NA	Proposed the use of dynamic interactive decision support using decision tree.	No	Yes,	In this approach a single portfolio is proposed to the decision maker in each iteration. The purpose of this paper is not to propose a new universal method for project portfolio selection, but only to formulate an idea within which such a procedure could be designed. No consideration of Sustainability.
17	*Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology*												
	(Abbassi et. al., 2013) Technovati	**Area:** PPS A Multi-stage decision framework of R&D project	Briefly includes various sustainability	A questionnaire was sent to 20 experts	No	The novelty of this approach is the proposed evaluation framework considering portfolio values and risks, projects'	NA	Yes	General R&D Project Selection	No	No	Yes	A Multi-stage decision framework of R&D project portfolio selection is provided which has four major modules i.e. (1) research projects

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	on - Journal – Elsevier	portfolio selection and balancing.	measures but not specifically	and senior managers with technical backgrounds.		interdependencies and separation between various research project categories.							categorization; (2) evaluation criteria; (3) mathematical model; and (4) constructing R&D project portfolio. However, how sustainability aspects can be catered are not discussed.
18	*Project portfolio management – There's more to it than what management enacts*												
	(Blichfeldt and Eskerod, 2008) International Journal of Project Management – Elsevier	**Area:** PPM Conduct various interviews in 30 companies, and identify key reasons why companies do not do well in relation to PPM.	NA	Based on a research project compromised of 128 in-depth interviews in 30 companies	No	This research identified problems in relation to PPM i.e. (1) Projects are not completed as per plan; (2) Management and employees feel they lack a broad overview of on-going projects; (3) People experience stress as resources are continuously reallocated across projects in order to make ends meet.	Yes, but in general as it is mainly a theoretical evaluation	Yes Large-scale qualitative study done via interview	The empirical study covers 30 companies from industries	No	No	Yes, qualitative evaluation	This paper is based on a large-scale qualitative study. The results are comprehensive but only deals with identifying the issue related to PPM. No PPS or PPM framework is proposed which caters for sustainability aspects.
19	*A fuzzy set approach for R&D portfolio selection using a real options valuation model*												
	(Wang and Hwang, 2007) Omega - Journal –	**Area:** PPS Simplify R&D portfolio decision making when market and technology dynamics lead to unavailable and unreliable data	NA	Collection of various (numeric) parameter values such as development cost and human recourse	No	The proposed approach can assist decision makers in selecting suitable R&D portfolios, while there is a lack of reliable project information.	Generic approach	Yes In terms of calculating fuzzy project and portfolio costs	Generic various projects	No	No	Limited In terms of obtaining fuzzy project and portfolio costs	The authors conclude that the proposed approach can assist decision makers in selecting suitable R&D portfolios, while there is a lack of reliable project information, which is often the case with many organisations. However, no new PPS framework is proposed which caters for sustainability aspects.
20	*Project Portfolio Management Phases: A Technique for Strategy Alignment*												
	(Antonio	**Area:** PPS	NA	The	No	The development of	Not	No	NA	No	No	No	Other then literature review on

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	and Madalena, 2009) Academic Journal World Academy of Science	A technique for the project alignment with the organisational strategy, in order to select projects that later-on can be considered in the analysis and selection of the portfolio.		proposed technique is independent of the business area of application, thus only generic indicators are discussed		proposed methodology for assessing the project alignment index can assist organisations to gain a awareness of market dynamics and speed up the decision process to improvement of the organisational performance.	specifically						PPS the main contribution of the paper is mainly towards the project alignment index calculation phase. This phase intends to quantify the data collected from various indicators, and then determine an index for each project in the evaluation process. Authors did not specifically talked about the integration of sustainability issues in the PPS process.
21	*The influence of business strategy on project portfolio management and its success — A conceptual framework*												
	(Meskendahl, 2010) International Journal of Project Management	**Area:** PPM and Sustainability A conceptual model considering strategic orientation, project portfolio structuring, success, and business success	NA	No information is available	The model's design is not limited to a specific project type or industry	The developed conceptual model expands existing theories in project portfolio management and theoretically contributes to establish a link between strategy formulation and strategy implementation.	No	No	NA	No	No	Theoretical but not supported by any real-world case empirical case study	The presents a detailed but only a conceptual model (supported by literature) considering aspects of strategic orientation, project portfolio structuring, project portfolio success, and business success. Authors did not specifically talk about the integration of sustainability while considering about strategic orientation, project portfolio structuring etc.
22	*Project portfolio management in practice and in context*												
	(Martinsuo, 2013) International Journal of Project	**Area:** PPM A review of project portfolio management as a rational	NA	NA	No	Summary of recent empirical research on PPM in practice in terms of methodology, key findings and Emerging issues and new gaps.	No	No	NA	No	No	NA	The paper is conceptual in nature and, therefore, no new empirical evidence is reported. However, prior empirical research is broadly covered, and particular attention is paid to

S. No.	Reference	Major Contribution	Area of Sustainability	Research Span or Duration	Specific to any domain / field	Features/ Benefits	Consideration of IT projects portfolio	Practical Evidence	Domain of case study	Tool Support	Method proposed for sustainability integration to PPS	Evaluation Results	Limitations w.r.t this research
	Management	decision process											suggesting avenues for further research based on the review.
23	*Diagramming qualitative goals for multiobjective project selection in large-scale systems*												
	(Martinez, Joshi and Lambert, 2011) Systems Engineering - Wiley Online Library	**Area:** PPS This paper develops decision-aiding diagrams of top- level goals and resources that complement the existing multi-objective combinatorial optimization models.	NA	A case study of allocating resources to a system of airports.	No But mainly applicable or useful for large-scale systems	The developed methodology can assist to the generation of PPM solutions via the optimization model.	No Provides a general approach	The application of path diagrams is demonstrated through a case study of allocating resources to a system of airports.	Airport Systems Such as transportation planning	Path diagrams	No	Yes	The major contribution of this paper is path diagrams that are developed to relate resources to goals. An identified limitation of this research is that only a project's positive contribution to system goals is considered while generating path diagrams. In relation to this research no new PPS framework is proposed which caters for sustainability aspects.
24	*Dominance-Based Rough Set Approach in Selection of Portfolio of Sustainable Development Projects*												
	(Zaras et al, 2012) American Journal of Operations Research	**Area:** PPS and Sustainability To assist the Board of Directors of the Community Futures Development Corporations (CFDC in selecting projects	Not precisely but decision making indicators have considered economic perspectives	Considered 29 municipalities	Municipalities.	The approach is useful for program managers for decision support to evaluate and select the projects. This approach consists of looking for reduced set of criteria that ensures the same quality of classification of objects as the original set of criteria.	No	Yes	Municipalities.	No	No	Yes	This study demonstrates that the use of Rough Set Theory is useful and helps decision making for programme managers in the municipal sector. However, the applicability of such an approach in other sectors/domains is not tested. Moreover, this research is not directly considering proposing a PPS framework, which caters for sustainability aspects.

2.7 Evaluation of Project Portfolio Selection Frameworks

In the past, several PPS decision models have been proposed to help organisations in selecting a suitable project portfolio selection model. These PPS models have used a range of techniques *e.g. Mathematical, Decision support, Financial, Interactive Method* etc. However, many of these models are not being used or have limited impacts on decision-makings for real-world project portfolio selection; this however, can largely differ from organisation to organisation. Moreover, it is also possible that a PPS model can be very useful in one context (e.g. to evaluate financial or risk evaluation), but it may fail to support the whole PPS decision processes at the organization level. For this purpose of this research, it was required to further evaluate selected PPS models to establish the possibility for extension and incorporating sustainability for the evaluation of IT projects. To perform such evaluation, first a literature review investigation to identify PPS contribution factors and features has been carried out. As an outcome of this investigation, "PPS Evaluation Criteria" have been constructed (presented in the next section) for the selection of suitable project portfolio selection (PPS) framework for the selection of IT project selection and for the inclusion of sustainably as another evaluation factor. Further, the resultant PPS evaluation criteria have been applied on nine (9) shortlisted PPS formworks, which have been previously identified via review chapter. To perform this evaluation, both a scoring model and a presentation layout have been developed to evaluate and present each of the selected PPS models against defined evaluation criteria. The outcome of the evaluation gave us three favourite PPS formworks that scored the maximum in relation to the need and defined aims of this research. In final stage of this PPS evaluation, selected portfolio managers of ADP evaluated these three selected PPS frameworks to select a best suitable one. The following subsections present these details.

2.7.1 Project Portfolio Selection Frameworks Evaluation Criteria

This PPS evaluation criteria determined the applicability of a PPS framework for this research, which has been built by integrating and adapting criterions from (Jeffrey K. Pinto, 2010), (Douglas J., 2013), (Abbassi et al., 2013) (Strang, 2011), and (Nowak, 2013) and after discussion with portfolio managers in a focused group workshop. The resultant PPS evaluation criteria include domain/field, realism, practical reliability/accuracy, capability to integrate with relevant tools or systems, monitoring. measuring ease of use, cost effectiveness, capability to integrate with relevant tools or systems, flexibility of change and qualitative and quantitative method flexibility. Complete definitions and details of the proposed PPS Frameworks Evaluation Criteria are presented as follows:

Sub-Criteria	Description
PPS domain/field	If the PPS framework is related to particular domain/field or industry e.g. construction, electronics, medical, engineering projects or IT projects. *"High = IT projects evaluation",* *"Medium = General applicability on different domains",* *"Low = Specific domain other than IT", and*

Sub-Criteria	Description
	"NILL = Only top leave concept of a framework is provided with no consideration or applicability to any domain".
Realism	An effective model must be able to reflect organizational objectives and must be reasonable considering such constraints on resources as "money" and "personnel". Moreover, the model must consider both commercial risks and technical risks. *"High = If the model is completely matching to the above description",* *"Medium = If the model is fairly matching to above description e.g. only effective for few organizational objectives instead of all",* *"Low = If the model is limited in matching to above description", and* *"NIL = If the model is not matching to anything in the above description"*
Practical Reliability / Accuracy	If the framework has been applied in one or more practical environments and the practical reliability and accuracy of the framework has been tested. *"High = If the model can be applied on various types of projects with accurate results and reliability",* *"Medium = If the model can be applied on few/selected types of projects with medium reliability of results",* *"Low = If the possibility of model's practical test is limited (e.g. no details guidelines are available) or it can be applied on just one type of projects with no reliability of results", and* *"NIL = If the model is very high level without any implementation or testing details"*
Capability to integrate with relevant tools or systems	The model should be easily modified if trial applications (could be visual tools) require changes. *"High = If the model is completely adjustable with the change of client application", e.g. changing the GUI tool to a spreadsheet tool for evaluation.* *"Medium = If the model is fairly adjustable with the change of client application" e.g. changing some of the calculations/formulas from GUI tool to Spread sheet for evaluation.* *"Low = If is difficult to change/adjust the model with respect to the application ", and* *"NIL = If the model cannot accept a change"*
Monitoring	Decision maker's involvement or provision of some interactive mechanism for a decision maker for controlling and overriding portfolio selections generated by any

Sub-Criteria	Description
	algorithms or models based on past project experience, and they may also receive feedback on the consequences of such changes. *"High = If the model fully supports decision maker involvement to override portfolio selection decisions."* *"Medium = If the model fairly supports decision maker involvement in most stages of the process to override or amend selection decisions ",* *"Low = If the model supports limited decision maker involvement in certain (only few of the) stages of the process.* *"NIL = If the model does not support decision maker involvement at all"*
Ease of Use	A model must be simple enough to be used by people in all areas of the organization, and it should be timely: It should generate information rapidly, and people should be able to assimilate that information without any special training or skills. This can include if any tool (or Visual) support has been provided. *"High = If anyone in the organization (e.g. ADP) with minimum project management knowledge can use the model.* *"Medium = If only expert (or experienced) project managers can use the model.* *"Low = If specialized training is required to use the model", and* *"NIL = If the model cannot be applied due to extremely complex expertise and/or tool requirements"*
Cost Effective / Econometric Viability	The cost of gathering, storing, and arranging information in the form of useful reports or proposals should be relatively low in relation to the costs associated with implementing a project (in other words, low enough to encourage use of the models rather than diminish their applicability). *"High = If the model's implementation cost (overall time/effort required for implementation) is extremely low".* *"Medium = If the model's implementation cost (overall time/effort required for implementation) is normal and/or near to average for other models".* *"Low = If the model's implementation cost (overall time/effort required for implementation) is high", and* *"NIL = If the model's implementation cost (overall time/effort required for implementation) is extremely high".*
Comparability	The model must be broad enough that it can be applied to multiple projects, and it must support general comparisons of project alternatives. *"High = If the model can be applied to multiple projects, and*

Sub-Criteria	Description
	support comparisons". *"Medium = If the model can be applied to few types of projects with limited ability of comparisons".* *"Low = If the model can be applied to somewhat similar projects without the support of comparing project alternatives", and* *"NIL = If the model cannot be applied on multiple projects".*
Flexibility of change	A model should be flexible enough to respond to changes in the conditions under which projects are carried out and robust enough to accommodate new criteria and constraints. *"High = If the model is completely matching to the above description i.e. highly flexible",* *"Medium = If the model is fairly matching to above description e.g. model is responding to changes but cannot accommodate new criteria, or vice versa",* *"Low = If the model is limited in matching to above description e.g. having limited flexibility to change some of the criteria", and* *"NIL = If the model is not flexible nor robust"*
Qualitative & Quantitative method flexibility	Results shows that taking only a Qualitative or the Quantitative portfolio selection approach can lead to oversight, safety problems, budget overruns, and/or outright failure. The model must be able to accommodate both qualitative or exclusively quantitative project selection parameters on safety and risks of complete failure of project. *"High = If the model support both* qualitative and the quantitative portfolio selection parameters without any limitation and also support parameters on safety and risks of complete failure of project*".* *"Medium = If the model support both* qualitative and the quantitative portfolio selection parameters with some limitation*".* *"Low = If the model support either of* qualitative or quantitative portfolio selection parameters, but not both. *And/Or the model is quite restricted on the selection of parameters".* *"NIL = If the model has limited and pre-defined either of* quantitative *or* qualitative *parameters,* but not both*".*

2.7.2 The Selected Existing PPS Frameworks for Evaluation

The following are the 9 x selected PPS frameworks.

	PPS Framework	Major Contribution	Major Features/ Benefits
1	An integrated framework for project portfolio selection	Project Portfolio Selection Framework. Outlines the project portfolio selection process into various stages with objectives and details where Each identified stage accomplishes a particular objective and creates inputs to the next stage.	The Framework is claimed to be extendable and the users are free to choose the techniques they suitable for each stage.Guidelines are provided to build a decision support system for project portfolio selection.
2	Portfolio Selection Methodology for a Nuclear Project	Project selection and evaluation methodology - A mixed-method action research approach to evaluate project proposals. First, portfolio selection and evaluation theories are explained through the project management and business disciplines. Mixed-method variations and examples are then reviewed (including limitations). Finally, an improved project selection and evaluation methodology is proposed.	An investigation into mixed-method i.e. integrated qualitative and quantitative portfolio selection model, to evaluate complex, publicly sensitive project proposals. The results show that how a mixed-method is useful to evaluate projects when scientists, subject matter experts, politicians, and citizens often differ on scope, budget, time, and quality priorities. The outcomes also suggest that it is dangerous to apply either a qualitative or exclusively quantitative method when evaluating publicly sensitive nuclear-related projects, because taking one or the other portfolio selection approach can lead to oversight, safety problems, budget overruns, and/or failure.
3	Strategic framework for sustainable project portfolio selection and evaluation	Strategic Framework: Proposed a high-level strategic framework for project portfolio selection and evaluation. Extension → Fuzzy rule-based multi criteria framework for PPS	A two-phased approach is proposed, in the first phase it is suggested that *planning* and *selection* should be done under strategic objectives; and in the second phase a balance scorecard approach is proposed to assess and evaluate the results of *planning* and *selection* phase. The multiple and conflicting organizational objectives can be used as an input variables in a Fuzzy Rule-Based (FRB) Framework to estimate the overall suitability of the potential project portfolios. Framework integrates data mining model using both Data Envelope Analysis and Evolutionary Algorithm (EA) to design the structure of the proposed FRB system.
4	Project Portfolio Selection Using	A new project portfolio selection methodology	In this approach the decision-maker is involved until the end of portfolio

	PPS Framework	Major Contribution	Major Features/ Benefits
	Interactive Approach	based on interactive approach is presented. The requirements for decision support techniques dedicated to project portfolio selection problems are formulated. Propose to use dynamic programming for identifying the best solution with respect to each criterion.	selection process. The other existing approaches assume that the information about the decision-maker's preferences is collected before starting the calculation procedure and the calculation can be done without decision-makers involvement. Use of a quasi-hierarchical approach to find a proposal (from many) for the decision maker and then decision-maker evaluates the proposal or make suggestions. Authors claim that this can help decision-makers to look into multi-criteria while selecting a project.
5*	Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology	A Multi-stage decision framework of R&D project portfolio selection. The paper also provides a balanced set of R&D project evaluation criteria i.e. a 0–1 nonlinear mathematical programming method for balancing portfolios and risks.	The proposed approach can be used to consider project interdependencies types and other constraints while R&D project portfolio selection. The proposed multi-stage decision framework captures the dynamic interrelation between different projects by considering their values and risks. The novelty of this approach is the proposed evaluation framework considering portfolio values and risks, projects' interdependencies and separation between various research project categories.
6	A fuzzy set approach for R&D portfolio selection using a real options valuation model	The development of a fuzzy R&D portfolio selection model to hedge against the R&D uncertainty. Fuzzy set theory is applied to model uncertain and flexible project information. The proposed approach aims to simplify R&D portfolio decision making when market and technology dynamics lead to unavailable and unreliable collected data for portfolio management.	In the developed fuzzy R&D portfolio selection model a fuzzy compound-options model is used to evaluate the value of each R&D project. The R&D portfolio selection problem is formulated as a fuzzy zero–one integer programming model that can handle both uncertain and flexible parameters to determine the optimal project portfolio. The proposed approach can assist decision makers in selecting suitable R&D portfolios, while there is a lack of reliable project information.
7	An R&D options selection model for investment decisions	Checklist method for project portfolio selection	This paper reviews the development of a project selection and evaluation tool that can be applied to a wide range of research, technology and investment decisions. Lockwood (1999) developed this original model and it is extended in this paper through an application on a small group of projects. The extended

	PPS Framework	Major Contribution	Major Features/ Benefits
			model mainly focuses on PPS evaluation with respect to investment decisions.
8	An organizational decision support system for effective R&D project selection	Organizational Decision Support System (ODSS) for R&D project selection	The proposed system supports the R&D project selection process at the organizational level. It provides useful information for decision-making tasks in the R&D project selection process. Object-oriented software engineering with Unified Modelling Language (UML) has been used in the design and implementation of the proposed ODSS. There are several decision tasks in proposed R&D project selection process, which include proposal submission, selection of external reviewers, peer review, aggregation of review results, panel evaluation and final decision.
9	A mixed R&D projects and securities portfolio selection model	Scenario generation approach for portfolio selection problem	Proposes a scenario generation approach for the mixed single-stage R&D projects and multi-stage securities portfolio selection problem. The major focus of this approach is mixed asset portfolio to increase the investors' benefit as compared to consider all the PPS factors to achieve a balanced portfolio. Moreover, t model requires construction of complex mathematical model based on evaluation criteria and constraints, which is a key to this framework.

The evaluation of project portfolio selection frameworks has been carried out in focused group workshops at ADP, which were scheduled for 5 consecutive days (two hours per day). In these focused group workshops each of the PPS frameworks was discussed. At the end participants completed the evaluation of PPS framework and the evaluation outcomes were recorded in an evaluation table. Moreover, using a questionnaire, the list of criterions for selecting a suitable PPS framework was presented and the respondents were asked to give their ranking. More details on evaluation, focused group workshop and rankings questionnaire are presented in Chapter 6 Section 6.1. The following is the outcome of the evaluation of the project portfolio selection frameworks by the experts based on the evaluation criteria and after applying the ranking to the evaluation criteria using the obtained rankings / weightages.

Evaluation of Project Portfolio Selection Frameworks based on the Focused Group Workshop Outcomes and (Ranked) Evaluation Criteria

PPS Framework	PPS domain		Realism		Practical Reliability/ Accuracy		Capability to integrate with tools		Monitoring		Ease-of Use		Cost Effective		Comparability		Flexibility of change		Method Flexibility		Total Score
Ranking/Weightage →		**3**		**5**		**4**		**3**		**3**		**5**		**3**		**4**		**3**		**4**	**150**
Archer et.al. (1999)	2	6	3	15	2	8	3	9	2	6	3	15	3	9	2	8	3	9	3	12	**97**
Strang, K. D. (2011)	2	6	3	15	2	8	3	9	1	3	2	10	2	6	2	8	2	6	3	12	**83**
Khalili, D. et. al. (2013ab)	1	3	2	10	1	4	1	3	1	3	2	10	2	6	2	8	2	6	1	4	**57**
Nowak, M., (2013)	1	3	3	15	0	0	2	6	2	6	2	10	2	6	2	8	3	9	2	8	**71**
Abbassi, M., et. al. (2013)	2	6	3	15	3	12	2	6	2	6	3	15	2	6	2	8	3	9	3	12	**95**
Wang, J. et. al. (2007)	1	3	1	5	0	0	2	6	2	6	2	10	1	3	2	8	2	6	3	12	**59**
Coldrick, S. et. al. (2005)	2	6	2	10	2	8	3	9	1	3	2	10	2	6	2	8	3	9	2	8	**77**
Tian, Q., et al. (2005)	1	3	3	15	3	12	3	9	2	6	3	15	2	6	3	12	2	6	2	8	**92**
Fang, Y., et. al. (2008)	2	6	3	15	2	8	2	6	1	3	1	5	1	3	2	8	2	6	2	8	**68**

The above evaluation outcome shows that the three frameworks "Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology" (Abbassi et al., 2013), "An organizational decision support system for effective R&D project selection" (Tian, Q., et al., 2005) and "An integrated framework for project portfolio selection" (Archer and Ghasemzadeh 1999) have scored the maximum in relation to the need and defined aims of this research. Precisely the framework proposed by Archer and Ghasemzadeh (1999) scored the highest score among all of the PPS frameworks. However, in this research top 3 selected PPS frameworks were taken into the next stage. In the next stage, the selected portfolio managers of ADP were interviewed to select the preferred PPS framework; details of this are presented in the Chapter 6 Section 6.1.3 of this thesis.

2.8 Conclusions

In this section, findings of the literature survey phase of this research are summarised and conclusions are presented:

a. This literature survey started by considering the aspects of corporate strategy and it was concluded that corporate strategy is associated with both organisational short- and long-term objectives. This is because corporate strategy is related to multiple actions in an organisation and an organisational *'strategy'* and/or *'strategic decisions'* are typically associated with various long- and short-term issues. Further, it has been discussed in Section 2.1 that various corporate strategy related things and typically associated issues are dealt in various levels of corporate strategy that include overall corporate, business or just operations. Here, the top-level strategy i.e. Corporate-level strategy look-after the aspects related to value added services to various or all business unites of an organisation (Keyes, J., 2016). Moreover, as discussed in Section 2.2, an organisation's corporate strategy is usually aligned with its *'mission statement'* that reflects its owner(s)' expectations. Thus, in terms of ADP, the organisational sustainability policies are to be mainly linked with *corporate-level* strategy. The other levels of corporate level strategy; for example, the second level of strategy, is concerned with actual business of an organisation and the third (last) level of organisational strategies are operational strategies. The major difference between *Business-level* strategy and *Corporate-level* strategy is that corporate-level strategy involves decisions about the overall organisation and the strategic business unit(s) focuses on the business-level strategy (Fairholm, 2009). The operational strategies are concerned with actual working to effectively deliver the corporate-level and business-level strategies in terms of resources, processes and people.

b. In relation to the implementation of sustainability strategy in an organisation (e.g. ADP), it has been concluded in this literature review that for the top management and/or business leaders of an organisations, it is important to have a clear and comprehensive sustainability strategy incorporated into organisational corporate-level strategy. This shows that it is the responsibility of company executives to communicate and have an overall alignment across all organisation entities on the strategic goals, which is only possible if they will have a clear and comprehensive sustainability strategy. Moreover, in order to achieve continuous reputation that is critical for long-term viability of an organisation, business leaders have to incorporate sustainability aspect into

corporate-level long-term strategies.

c. While looking into a balanced sustainable development it has been evident via this literature survey that taking a balanced approach to sustainability has grater advantages and each part of the balanced sustainable development often supports each other. For example: (a) if organisations focus on social and environmental issues, profitability (economic growth) often follows; (b) social initiatives or an organisation usually have an impact on consumer behaviour and employee performance; and (c) environmental initiatives such as energy efficiency and lessening pollution can have a straight impact on dropping waste.

d. The literature survey also concludes that Green and Sustainable IT initiatives need to bring various cost savings opportunities. This could be by prioritization of projects, increasing energy efficiency and reducing consumption by encouraging telecommuting that offers advantage of reduced travel, reduced office space and flexible working environment to employees. Thus in order to achieve Green IT, organisations need to be selective in project selections that enable reduction of IT energy and operating costs, and reduce the environmental impact of IT practices.

e. While comparing the requirements of sustainable development and project (portfolio) management it has been noted that there are many challenges faced by the research community about integrating sustainability into project management. This is largely because, often the requirements of sustainable development and project management are difficult to align together and they do have some major differences in their concepts i.e. in-terms of short term or long term targets, interests, life spans, priorities, preferences and overall effects. Thus based on the literature review conducted in this chapter, this can be concluded that the requirements of sustainable development and project management are difficult to align together as they have some major differences in their concepts. Moreover, there are also a number of implications of integrating sustainability in projects and project management, and they are usually related to all processes, methodologies and standards of project management. Thus, organisations like ADP need to be careful while generating sustainability policies as it can affect the proficiencies of the project manager(s) and the traditions how organizations make strategic plans and govern their projects.

f. The literature review on existing project/portfolio management lifecycle models shows that only the “pre project/initiation” phase is concerned with project(s) selection, where ideas are formulated and the business reviews are done. These business reviews evaluate on whether this is a feasible project, or evaluate an element of a project to be included within the portfolio of projects that are currently running. At this stage all measureable elements of sustainability are considered and evaluated as complete package that can include various aspects of sustainability such as planet (environmental aspect), people (social aspect), profit (financial aspect), process (governance aspect) and product (technical aspect). Henceforth, in relation to this research only the “pre project/initiation” phase of PPM is relevant to the sustainability

integrating for the selection of a project. Thus, in this research Project Portfolio Selection (PPS) has been selected instead of PPM to integrate sustainability aspects for the selection of IT projects. This is primarily because this research is mainly concerned to support "program managers" in evaluating in the pre project/initiation phase whether a particular IT project or an element of a particular IT project is feasible. The other phases of project (and portfolio) management such as executing/controlling, closure and reviews are mainly concerned with the project management and not program management; and thus, they are outside the scope of this research.

g. Although project management is existent since very long, the history of project portfolio management and selection is not very old. During last few decades project management has been there but it was only recently accepted as a major management discipline (Maylor, 2010). That was the time when many project management tools came into existence, such as Gantt charts, that were quickly adapted by the corporate industries. Later was the start of project portfolio management era, as known today, which came into existence when originations went bigger and also started operating globally. It was during late 1990s when researchers and project managers started to realise the strong need for a way to coordinate the project portfolio (Henriksen and Traynor, 1999), and to set the strategic priorities between various projects and find a balance between those projects (Madic et al., 2011). Those theories were further developed and the first major literature written on portfolio selection topic was a book written by the Nobel Prize winning economist, Harry Markowitz (Birgisson, 2012). According to McGrath (2004), in the beginning of project portfolio research, managers also started to ask questions like: How to start a project? And, How to prioritized them with limited resources? These and other such questions of managing organisational-wide projects actually further pushed the development and analysis of project portfolio management (McGrath, 2004). Currently, project portfolio management and project portfolio selection is becoming one of the fastest concepts within the field of project management (Madic et al., 2011). Moreover, in (Birgisson, 2012), a study has been conducted where the scholarly database *science direct* was used to find the number of articles that mentioned "Portfolio Management" in the international *Journal of Project Management* published each year since year 1999. As per the survey results, it is only since 2007 when the PPM research became active. Moreover, recently in 2006, the Project Management Institute has developed and published the first edition of *Standards for Portfolio Management*, and the next one was released in 2008 with changes that were made after reviewing hundreds of recommendations for improvements from various individuals. This shows that PPS is an emerging field and there are still a lot of challenges still remaining for the research community.

h. In order to establish the state of the art on PPS models to include sustainability and achieve Green IT, in this chapter a systematic literature review has been conducted. The technique adopted to conduct this review made it possible to explore, organize, and summarise contributions related to the research topic. This enables assessment of the extent of existing evidences on this topic. The review of existing Project Portfolio Selection (PPS) models had main

objectives to identify the extent of current research on PPS models and incorporation of sustainability aspect in PPS to achieve Green IT. In this phase of the literature review it has been concluded that most of the existing PPS approaches (as presented in the comparison table); for example by (Pourahmadi, Nouri and Yaghoubi, 2015), (Gome de and de Barros, 2014), (Khalili-Damghani et al., 2013) etc., introduce a high-level PPS framework with abstract information on each component of the framework. In (Benaija, K. and Kjiri, L., 2015) a method of projects selection is described as part of the projects portfolio management, which uses an interactive approach due to the involvement of decision makers throughout the decision making process. The proposed interactive approach works on criteria that include *"value maximization, risk minimization and strategic alignment"*. However, in this approach no attempt has been made to define a sustainable project portfolio selection framework. Moreover, the approach itself is very useful but it does not analyse all the possible portfolio alternatives, and it is focused on further analysing the pre-classified alternatives selected by the managers. Da Silva et al. (2016) proposed a 2-step interactive approach for project portfolio selection. These interactive functionalities provided via these chats enable project managers refine the PPS model using software. However, in comparison to this approach, this approach does not consider sustainability factors in project portfolio selection. Similarly, Pourahmadi, Nouri, and Yaghoubi (2015) presented a scenario based mathematical model for project portfolio selection, which can be used when project parameters are under uncertainty. The preliminary results of their work indicate that profitability can be increased by considering different scenarios instead of one single scenario. In relation to this approach, this approach does not propose an end-to-end project portfolio selection framework or considers sustainability factors while selecting projects. Gome de and de Barros (2014) presented an approach to solve project portfolio selection problem in the presence of limited resources and multiple criteria. The approach encourages and guides decision-making based on AHP, but cannot be used as the sole method for project portfolio selection. Similarly, the PPS framework presented by Nasrin and Duecker, (2013) is mainly providing guidelines for organizations pursuing waste minimization, process optimization, or improvements in energy use. But, it is not considering how these (or other) sustainability factors can be incorporated into PPS framework. In another approach presented by Heising (2012), the proposed Conceptual Framework is based on existing literature and interview questions and not by applying to a specific domain. There has been some research in considering PPS for other domains, such as urban planning in (Andersson and Lyden, 2006), where generic analytical conclusions based on previous project experience on how to use a phased approach to create and manage a project portfolio in the urban planning are presented. In (Bernard and Sami, 2011) the benefits and shortcomings of the project portfolio selection methods are recognise in order to assist them in with various choices, but not a complete design of PPS framework is proposed. Recently various other PPS abstract frameworks or theories have been presented; for example by (Wang and Hwang, 2007), (Blichfeldt and Eskerod, 2008), (Strang, 2011) (Martinsuo, 2013) and (Gutierrez, and Magnuss, 2014). However, in there is no PPS or

PPM framework is proposed which caters for sustainability aspects; also, no practical case studies are provided. Very recently in (Nowak, 2013), an idea has been formulated within which a new universal method for project portfolio selection could be designed. However, this is an in-progress work and in future authors plan to propose a dynamic interactive decision support technique combining a decision tree and interactive approach. The closest literature found during this literature review was in (Abbassi et. al., 2013) where a Multi-stage decision framework of R&D project portfolio selection is provided which has four major modules i.e. research projects categorization; identifying research projects evaluation criteria; constructing mathematical model; and research projects evaluation and constructing R&D project portfolio. However, it is not clear that to what extent and how sustainability aspects can be catered-for in the framework, if any. Thus, based on the outcomes of this state of the art review this can be concluded that, there is still a lack of PPM and PPS framework along with practical case study that also caters for sustainability aspects while selecting an IT project.

i. After doing the extensive literature review, a shortlisting of nine candidate PPS frameworks was completed to select an appropriate PPS framework to extend and to include sustainability for the selection of IT projects. To make this selection, PPS framework evaluation criteria were generated and refined using questionnaire. Further, rankings were also obtained for each of the criterion from domain experts. The resultant evaluation criteria and rankings were applied on the 9 x selected PPS frameworks. The outcome of the theoretical evaluation showed that the 3 x frameworks i.e. "Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology" (Abbassi et al., 2013), "An organizational decision support system for effective R&D project selection" (Tian, Q., et al., 2005) and "An integrated framework for project portfolio selection" (Archer et. al., 1999) scored the maximum in relation to the need and defined aims of this research. In the next stage, the selected portfolio managers of ADP have practically evaluated these PPS frameworks based on their experience and expertise. As a result, three PPS frameworks were identifed, same as in the theoretical evaluation, for the next stage of another interview-based practical PPS frameworks evaluation to select one final PPS framework. Finally, interviews were conducted with selected project portfolio managers to select one PPS framework. As a result, the PPS framework presented by (Archer et. al., 1999) has been selected as more appropriate to customise, extend and also to include sustainability for the selection of IT projects.

Based on the above summarised conclusions of the literature review and identified shortcomings, this research aims to come up with a suitable framework/model of IT projects portfolio selection that will also cater for sustainability issues. To achieve the research aims, the adopted research methodology including the adopted approaches for data collection and analysis are presented in the next chapter of this thesis.

Chapter 3: Research Methodology

This chapter introduces the research methodology of this research. In this regard, first a brief introduction on the need and comparison of possible research methodologies for this research is presented followed by the details on the selected and applied research methodology. Then, the adopted approach for data collection and analysis is presented, which led us to propose a sustainable project portfolio selection framework for this research. Finally, various characteristics related to the reliability and validity of the collected data are discussed and concluded.

3.1 Introduction

In general, a research methodology is the process used to collect information and data for the purpose of making decisions, recommendations and to come-up with new theories or *Mode*ls (Creswell, 2013). In the literature (such as in Bernard and Gerry, 2009 and Ryan and Bernard, 2000), a number of different research methods are presented to execute a particular research that include *qualitative* research, *quantitative* research, *mixed* methods that include both *qualitative* and *quantitative* methods, *action* research and *case study* methods etc.

The choice of selecting a particular research methodology is dependent on the type of research that needs to be carried out. One of the major differences between *qualitative* and *quantitative* research is that, the *qualitative* method is used when it is usually unknown what to expect and data is gathered to determine what the big picture is, but the picture is very unclear before all of the data is gathered and analysed (Bernard and Gerry, 2009). Quantitative methods mainly use *numerical* data and it starts with developing a hypothesis, which is then tested with one of more statistical techniques to come up with new knowledge. Quantitative research is more used to *quantify* problems by analysing data that is already known and to identify ways to fix those problems (Creswell, 2013). Using questionnaires to implement research and collect data is considered as one of the most popular method of quantitative research (Bernard and Gerry, 2009). In comparison to qualitative method, large sample size is used in quantitative method in order to obtain a generalized research outcome(s). The other types of research methods i.e. *mixed* and *action* research methodologies are also very prevalent. In mixed research method, both the quantitative and qualitative research methods are integrated to solve a research problem (Creswell, 2013). In *action* research, there is usually no real planning to resolve a problem, it goes with trials and action is taken, and if the trial is not successful, then the action is addressed and a new action is used to address/try the problem (Patton, 2002). A case study research provides an understanding of a complex issue in comparison to what is already known through previous research. In the case study method, usually a detailed intensive study of a unit, such as of an organisation is carried out (Bruce, 2008). In the following tables 3.1, 3.2 and 3.3 the

qualitative, quantitative and case study methods along with their properties have been listed (Creswell, 2013) (Bernard and Gerry, 2009). More details and justification of the selected methodology is presented in Section 2.

Table3.1: Qualitative Methods

- Methods include focus groups, in-depth interviews, and reviews of documents for types of themes
- Primarily inductive process used to formulate theory or hypotheses
- More subjective: describes a problem or condition from the point of view of those experiencing it
- Text-based and No statistical tests
- More in-depth information on a few cases
- Unstructured or semi-structured interview response options
- Can be valid and reliable: largely depends on skill and rigor of the researcher
- Time expenditure lighter on the planning end and heavier during the analysis phase

Table 3.2: Quantitative Methods

- Surveys, structured interviews & observations, and reviews of records or documents for numeric information
- Primarily deductive process used to test pre-specified concepts, constructs, and hypotheses that make up a theory
- More objective: provides observed effects (interpreted by researchers) of a program on a problem or condition
- Number-basedLess in-depth but more breadth of information across a large number of casesFixed response options
- Statistical tests are used for analysis
- Can be valid and reliable: largely depends on the measurement device or instrument used
- Time expenditure heavier on the planning phase and lighter on the analysis phase

Table 3.3: Case Study Methods

- A case study can be of various types i.e. *exploratory*, *explanatory*, *descriptive*, *intrinsic, instrumental and collective*
- ***Exploratory*** is mostly performed when the aim is to explore a process in practice; *explanatory* case study is usually used for doing causal investigations
- ***Descriptive*** case studies require development of descriptive theory before starting the research
- ***Intrinsic*** *is applied* when the researcher has an interest in the case to investigate a fundamental theory.
- ***Instrumental*** is mostly used when the case study is used to understand more than what is obvious to observer;
- ***Collective*** is appropriate when a group of cases are required to be studied instead of focusing on a particular phenomenon
- A case study method is a detailed intensive analysis of a person, group or an organisational unit performing a particular process (i.e. ADP)

While investigating the choice of research methodology of existing studies in the literature that are most relevant to this research, it has been found that *qualitative* and *explorative case study* methods are the ones used to explore similar phenomena as being explored in the research. For example: In Abbassi et. al., (2013) exploratory case study has been used where the authors have considered different stages of various real life R&D project portfolio selection process and proposed a multi-stage decision framework based on a balanced set of R&D project evaluation criteria. In (Linton, Walsh and Morabito, 2002) a method for the analysis, ranking and selection of R&D projects from a portfolio is outlined and demonstrated. It is proposed that an objective multi-criteria decision-making method can be used to split a portfolio of projects into accept, consider further and reject sub-groups. In this regard, they *explored various case studies* and presented a summary of the different metrics proposed in the literature for the evaluation of R&D projects and portfolios. Similarly, in (Gutierrez, and Magnuss, 2014), through the *qualitative interview study* of three industrial companies, they explored how different decision-making approaches are combined in PPM and to some extent in project selection. They found that rational and formal decision-making processes are experienced as more legitimate than informal and non-rational ones. In (Bernard and Sami, 2011), a systematic overview

of approaches to project portfolio selection has been provided to identify improvement opportunities. This is mainly an explorative and qualitative review, which tries to fills a gap in the literature by providing researchers and practitioners with an overview of approaches and a better understanding of the shortcomings of current approaches. Furthermore, in (Nowak, 2013), a concept of a new methodology based on interactive approach is presented to help decision maker in evaluating a project proposal. The main feature of the proposed solution is that how various criteria of project selection are considered, including financial, technical, social and environmental factors. This research has been based on exploring various approaches proposed in the literature to come up with the requirements for decision support techniques dedicated to project portfolio selection.

Due to the nature and aim of this research work, that is, to come up with a suitable framework of IT projects portfolio selection that will also cater for sustainability issues *a mix of both qualitative research and case study methodology* has been adopted. Here, the case study method is selected to investigate *how IT projects are being currently selected in terms of sustainability* and *how the IT Project Portfolio Selection (PPS) is being done in ADP*. And, qualitative method has been selected to gather an in-depth understanding on *when* and *how various factors in PPS are considered by selected organisation while making decisions in the selection of IT projects*.

3.2 Justification of Selected Research Methodology

This section explains: (1) why in this research a qualitative method has been adapted to gather an understanding on various factors in PPS for the selection of IT projects in selected organisations; and (2) why case study method has been chosen to investigate the overall PPS process for the selection of IT projects in ADP. In this regard, justification on the selections of qualitative research is presented followed by the case study methodologies.

Qualitative research is the exploration attempt to increase an understanding of various factors in PPS for the selection of IT projects in various organisations. In general, qualitative research includes observation, focused groups and interview methods. Here, the observation method involves looking and listening to people very carefully to discover particular information either *directly* or *indirectly* (Campion et al., 1994). In the perspective of this research, observation methods is not suitable because it is practically not possible to get the required results through observation, mainly because PPS is a lengthy process and involves various policy and strategic decisions by the top management. In comparison to the observation method, focused groups and interviews are the most suitable method of qualitative research for collecting qualitative data, and in this research focused groups interviews method has been selected. This is because, in order to get more information about the various sustainability related factors in PPS that are being considered by their organisations, there is need to ask some similar basic questions as well as open questions from the participants. This semi-structured focused groups approach provides an information that is richer and has a deeper insight into the phenomenon under study (Kvale, 1996). More details on why in this research focused groups approach is consider more appropriate then unstructured and structured interview methods are discussed later in the *Data Collection for Analysis* section of this chapter.

As discussed above, due to the exploratory nature of this research; i.e. to gather an in-depth understanding on why and how various factors and especially sustainability are being (or can be) considered in PPS, adopting an Action Research methodology has not been found suitable. This is because Action Research (which also known by many other names and variants, including participatory research, collaborative inquiry, emancipatory research, action learning, and contextual action) is aimed at "learning by doing" where a group of people identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again (O'Brien, R., 2014). However, such an investigation is outside the scope of this research. According to Gilmore et al., (1986), "Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in practically changing it in what is together regarded as a desirable direction".

A case study can be of various types i.e. *exploratory*, *explanatory*, *descriptive*, *intrinsic*, *instrumental and collective* (Bruce, 2008). Here, *exploratory* is mostly performed when the aim is to explore a process in practice; *explanatory* case study is usually used for doing causal investigations; and *descriptive* case studies require development of descriptive theory before starting the research (Baxter and Jack, 2008). Moreover, *Intrinsic is applied* when the researcher has an interest in the case to investigate a fundamental theory. *Instrumental* is mostly used when the case study is used to understand more than what is obvious to observer; and *collective* is appropriate when a group of cases are required to be studied instead of focusing on a particular phenomenon (Creswell, 2013). In short, a case study method is a detailed intensive analysis of a person, group or an organisational unit performing a particular process where a researcher is interested in; and for the case study of ADP, it is an *exploration* to investigate the overall PPS process for IT projects selection. It is important to note here that this ADP case study must not be confused with above-mentioned qualitative research as a case study itself can be based on any mix of quantitative and qualitative evidence in general, a good case study uses a number of different research tools to increase validity of the collected information (Kvale, 1996). For example, a researcher can use both qualitative and quantitative approaches and different data collection mechanisms such as surveys, interviews, literature reviews, evidence collection etc. Thus, in this research, in order to collect reliable data and have different views of the phenomena being explored, both *focused groups* and *evidence collection* methods are selected for the ADP case study. No single source in case study method has a complete advantage over the others; rather, they might be complementary and could be used to support each other. Thus, a case study should use as many sources as are relevant to the study. Therefore, in the case study of ADP, it will also be ensured that data is collected from two different sources; i.e. both *focused groups* and *evidence collection*, so that the information is verified from different angles.

3.3 Adopted Research Methodology

As discussed above, this research is based on both the qualitative and case study methods to come-up with a suitable framework of IT projects portfolio selection in Abu Dhabi Police (ADP) that caters for sustainability issues. In this section, overall

research phases is presented along with the adopted research methodology with the help of diagram and then explain its various steps.

The following Figure 3.1 shows the various phases of this research. This research started with a generic literature review on PPS to understand the current status of the research in this domain. This has enabled us to identify the shortcoming in existing research i.e. *the need to have a suitable framework of IT projects portfolio selection that will also cater for sustainability issues*. Here, ADP has been selected because this is one of the largest and well-structured organisations in Abu Dhabi. Overall, ADP has 34 departments across Abu Dhabi; and within each department, there are between 6-8 sections and under each section there are between 2-4 branches are operating. Currently, ADP is running; as well as planning to initiate, many inter- and cross-departmental IT projects, and thus looking to investigate a sustainable PPS framework for the selection of their IT projects.

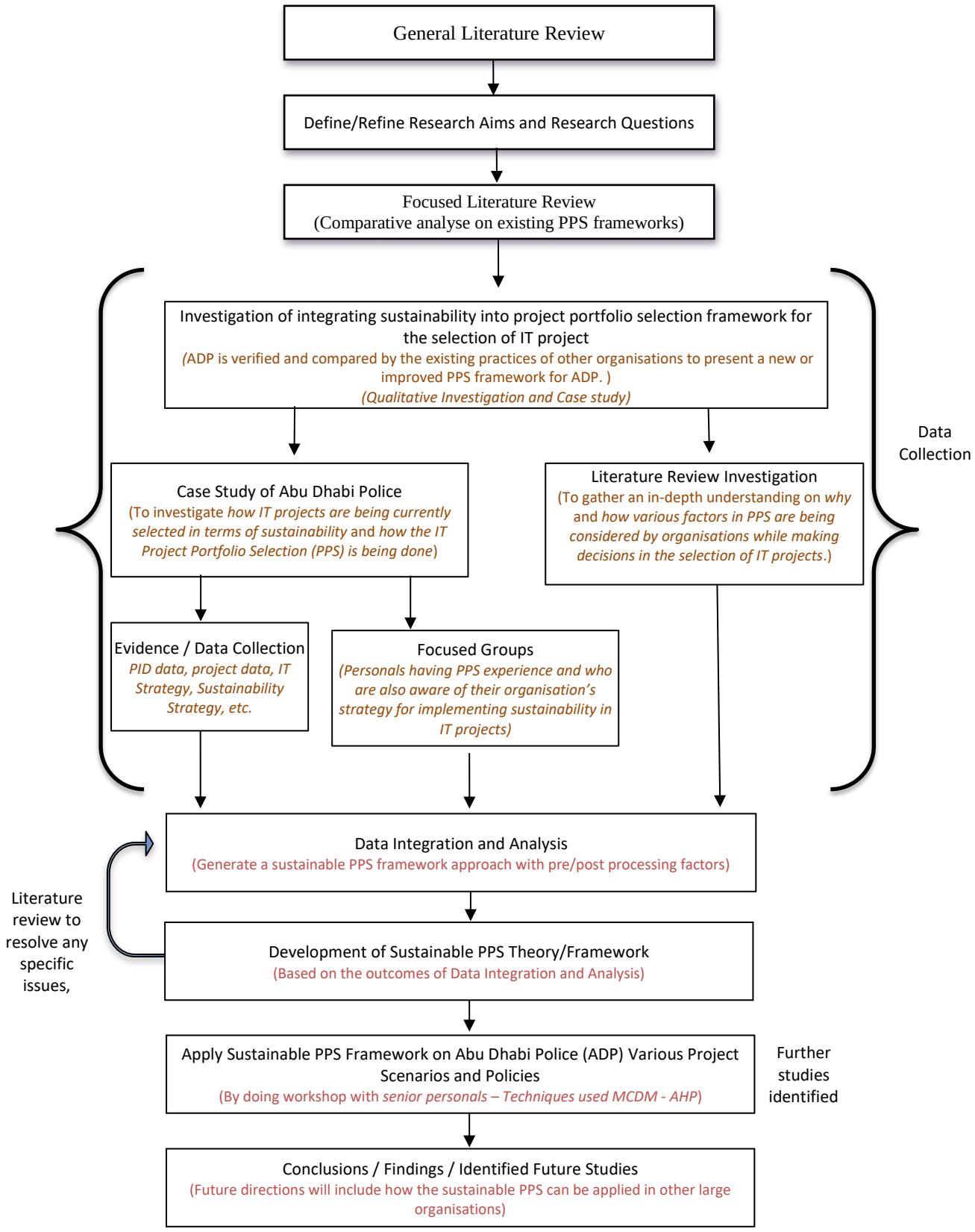


Figure 3.1: Research Phases and Methodology

Based on the initial literature survey findings, research questions of this research are defined. Then, a systematic and focused literature survey was conducted in order to establish the state of the art on existing PPS *Mode*ls to include sustainability. The systematic and focused technique adopted to conduct this review has not only made it possible to achieve a high-level of accuracy and reliability in results, but also to explore, organise, and summarise existing contributions related to the research topic. In this way, the extent of existing evidences on the topic could be assessed; and consequently, formulate the research methodology to conduct this research.

After conducting the focused literature review, a research methodology has been identified that is suitable for this research (as discussed above). As shown in Figure 3.1, to carry out an investigation of integrating sustainability into project portfolio selection framework for the selection of IT project, both qualitative and case study methods are adopted. In this regard, the case study has been carried out with Abu Dhabi police to collect evidences related to this research as well conducting focused groups exercises with selected employees to obtain research data.

In the next step, a detailed investigation shown as data integration and analysis in Figure 3.1, have been carried out. This data integration and analysis served as the bases for proposing a new approach and a framework for a sustainable PPS with pre/post processing factors along with detailed descriptions and justifications, details of which are discussed in the later chapters of this thesis. Once this has been done, the developed framework and PPS theories are applied within ADP to test the practical applicability of the proposed framework and to collect results. This has been carried out both on an existing and an upcoming IT projects in ADP. The outcomes of this activity are also discussed in later chapters of this thesis. Finally as shown in Figure 1, towards the end of this thesis the shortcoming(s) of this research are presented, conclusions are discussed and future research topics that can be investigated in this area are listed.

In order to collect data for this research, sustainability policies and project portfolio selection approaches for the selection of IT projects have been examined. This has been done at ADP and the related literature has been examined. Here, ADP has been taken as a main case study by making formal arrangements to access the ADP's portfolio selection procedures and sustainability strategy as part of this research. Also, as explained above, ADP is one of the largest organisations in Abu Dhabi having 34 departments and under each department there are many sections and branches that are currently executing many IT project and many others are in the planning phase.

Before conducting above-mentioned focused group workshops, various interview methods were considered that include *unstructured*, *semi-structured* and *structured*. Structured interviews contain a structured sequence of questions to be asked in the same way of all interviewees. One of the major disadvantage of structured interview is that, if a respondent indicates that they do not understand a question or the depth of information requested, the interviewer is generally limited to providing only a previously scripted explanation. Moreover, there is no option to discuss anything beyond the pre-defined questions' list. With unstructured interviews, a researcher usually has a clear plan of the interview but minimum control over how the respondent answers. An example of unstructured can be that a researcher visits an office, sits down with an interviewee and asks, "What do you do?" Now, such interview conversation can go in many directions, and will vary much by the

interviewee. In short, in unstructured interview, the interviewer or researcher does not have much control over the course of the discussion. Thus, such method is not suitable for this research. Unlike structured and unstructured interviews, the significant quality of semi-structured interviews is that they have a flexible and fluid structure depending on the information being received (Campion et al., 1994). In semi-structured interviewing, a guide is used, with questions and topics that must be covered. The interviewer has some choice about the order in which questions are asked, but the questions are standardised, and probes may be provided to ensure that the researcher covers the correct material. However, for this research there is a need to collect project data and then apply PPS on it in different phases and activates. The above-discussed limitations show that interviews methods were not suitable for this research.

In the following section, detailed methodology is described including data collection concerning each of the research objectives.

3.4 Methodology to Achieve Individual Research Objectives

The defined objectives of this research have been further divided into various data collection, analysis and related activities. The outcome of the activities associated with all objectives 1-5 contributed toward the aim of achieving a sustainable PPS framework based on a balanced corporate and sustainability strategy. The following activity diagram (Figure 3.2) shows the steps made to achieve the research objective 1 i.e. "to review and analyse the exiting PPS frameworks in order to establish the possibility for incorporating sustainability for the evaluation of IT projects".

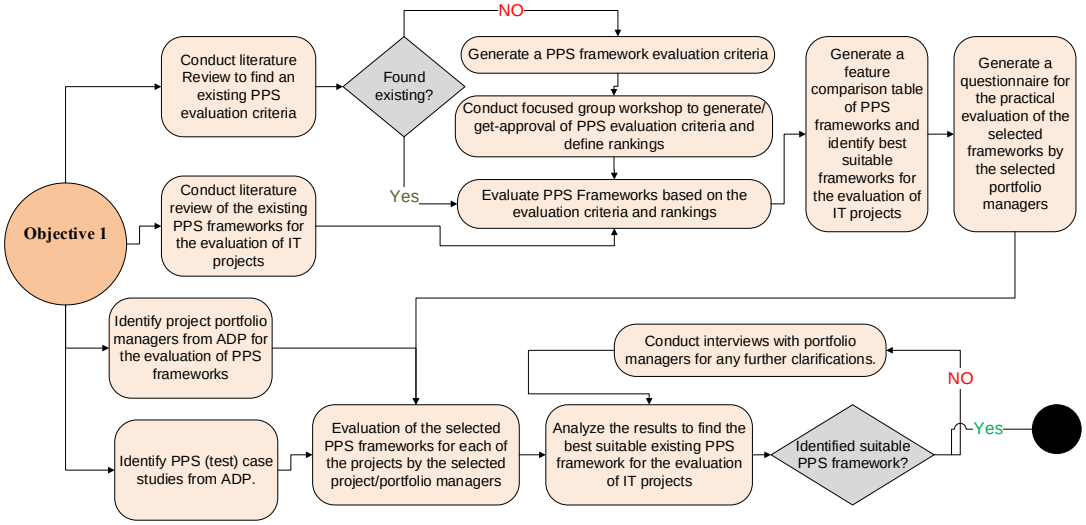


Figure 3.2: Activity Diagram of Research Objective 1

Figure 3.3 shows the steps involved to achieve objective 2 i.e. "determine how sustainability can be integrated into a PPS framework as a stage for the evaluation of IT projects". Further, Figure 3.4 shows the steps involved to achieve objective 3 and 4. Here, objective 3 is "determine the relationship between sustainability and other IT project portfolio selection factors" and objective 4 "determine the relationship between sustainability with other PPS factors by taking sustainability as the main optimisation factor". Both objectives 3 and 4 require primary data collection from the same project/portfolio managers from ADP in focused groups workshops. Therefore,

some of activities of both objectives 3 and 4 have been merged together (as shown in Figure 3.4).

Finally, Figure 3.5 shows the steps involved to achieve objective 5 i.e. “formulate a sustainability project selection policy, which incorporates both corporate level strategy and sustainability strategy”. Once this and all the above activities were performed they lad us towards the development of a sustainable PPS framework for the selection of IT projects in ADP.

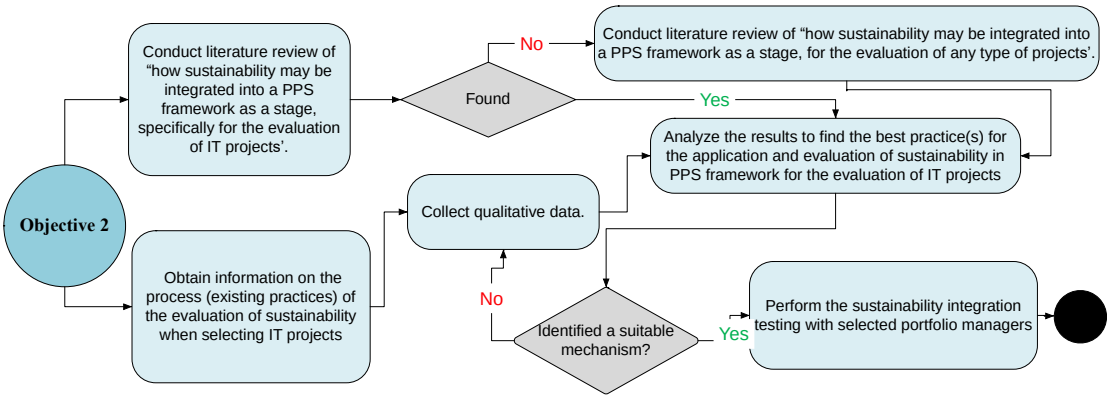


Figure 3.3: Activity Diagram of Research Objective 2

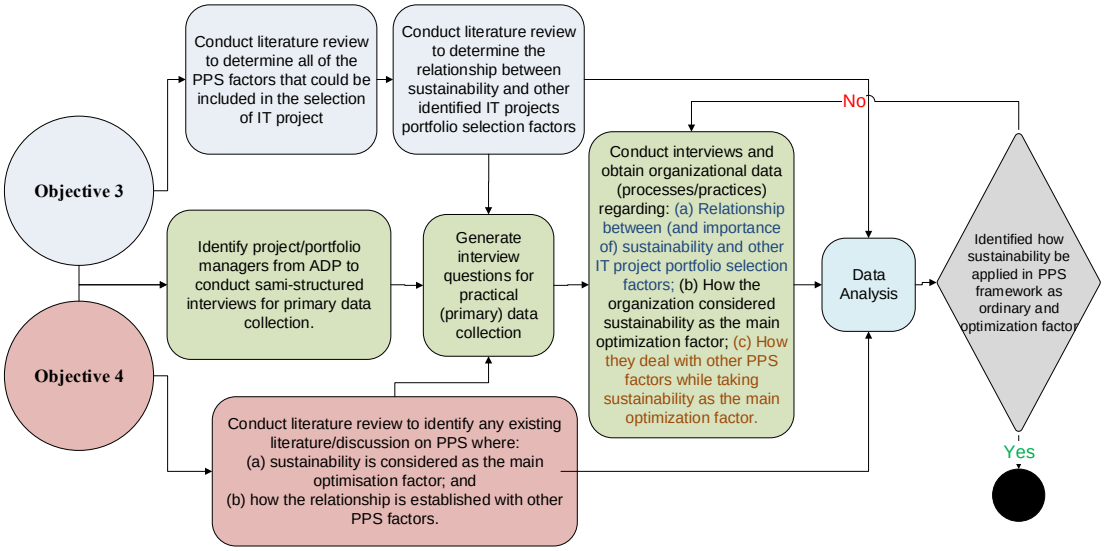


Figure 3.4: Activity diagram of Research Objective 3 and 4

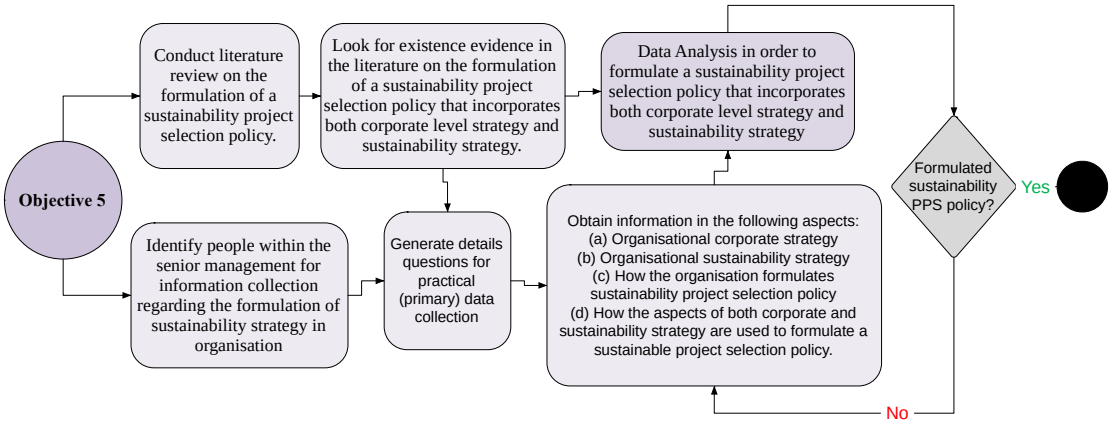


Figure 3.5: Activity Diagram of Research Objective-5

3.5 Project Portfolio Selection Decision Making

This research involves dealing with more than one criterion i.e. the portfolio selection and balancing involves the consideration of large criteria to choose one or more best alternatives (projects) from a set of available alternatives (projects). In a project management context of an organization, project selection is the intermittent activity involved in selecting a portfolio from available project proposals, which somehow obey to the goals established by the organizational such as a project do not exceed available resources or break other constraints (Archer & Ghasemzadeh, 1999). The MCDM or MCDA are well-known acronyms for *multiple-criteria decision-making* and *multiple-criteria decision analysis*. In Chapter 2, an argument is established on the suitability and selection of MCDA method over other applicable methods. Although, a wide variety of project selection models has been developed in recent years; including linear programming, scoring models and checklists, MCDA is used for structuring and solving decision and planning problems involving multiple criteria, with the purpose to support decision makers. As per Lopes and Almeida, (2013), MCDM aid and support people and organizations to make decisions under the influence of a variety of criteria, where multiple (rather than single) criteria characterize the notion of "the best" (or optimal), as is prevalent in the areas of economics, engineering, management and business.

The MCDM in this research was selected to help choosing the "best" alternative from a set of available alternatives. It is important to note here that the word "best" here may not be the “best” project in every aspect, but it can be interpreted as the most preferred alternative. In terms of portfolio balancing, it is the grouping of alternatives into different preference and selecting a project or projects that are most preferred against several criterions. Such preferences make sense for the decision maker to choose a solution, which otherwise is a difficult thing to do.

Multi-Criteria Decision Analysis, or MCDA, is being used by the Natural Resource Leadership Institute (2016) as a valuable tool, which they apply to many complex decisions. It is widely being used for dividing the decision into smaller parts and then performing an analysis to produce a meaningful solution. As acknowledged by the Natural Resource Leadership Institute (2016) “MCDA is most applicable to solving problems that are characterised as a choice among alternatives. It has all the characteristics of a useful decision support tool: It helps us focus on what is important, is logical and consistent, and is easy to use”. Like this research, the Natural

Resource Leadership Institute use MCDA for group decision-making and to provide a unique ability for people to consider and talk about complex trade-offs among alternatives. Consequently, MCDA helps people think, query, adjust, balance and decide, and they may go through various cycles before they finally decide. In general, the MCDA problems are comprised of five components listed below:

a. *The overall goal / objective e.g. to select best alternatives*
b. *Decision makers with opinions e.g. portfolio managers*
c. *Decision alternatives – portfolio of projects*
d. *Evaluation criteria – projects evaluation criteria*
e. *Outcomes associated with alternative – project selection policies and their outcomes*

In terms of classification, there are different classifications of MCDM problems and methods are proposed by various researchers. This research falls into the *Multiple-criteria evaluation problems space. The Multiple-criteria evaluation problems* such as project portfolio selection, are problems consist of a predetermined number of alternatives, unambiguously known in the beginning of the process. In the application of MCDM, each alternative is represented by its performance / score / rank in multiple criteria. The goal or problem may be defined as finding the best alternative or finding a set of good alternatives. Under this method, decision makers can also "sort" or "classify" alternatives, where “Sorting” refers to placing alternatives in a set of preference-ordered and classifying refers to assigning alternatives to groupings (based on shared properties). The Analytic hierarchy process (AHP) is the most widely used method for the application of *Multiple-criteria evaluation problems* / MCDM, which is discussed in the next section (Saaty and Peniwati, 2013).

3.5.1 The Analytic Hierarchy Process (AHP) Method for MCDM

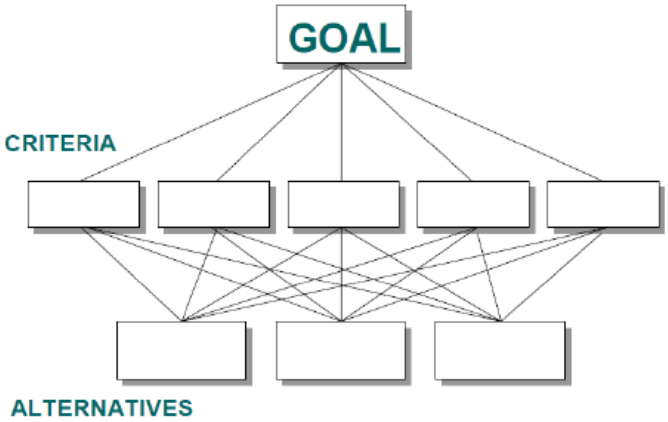
Analytic Hierarchy Process (AHP) is a structured and transparent way of making decisions using a step-by-step process. AHP’s step by step process simplifies decision-making, enables collaboration and improves the quality of decisions (Saaty and Peniwati, 2013). Although, AHP can be used by individuals working on straightforward decisions, it is most useful when working on complex problems, especially those with high stakes, involving human perceptions and judgments, whose resolutions have long-term repercussions, such as project selections from a portfolio of projects (Bhushan and Rai, 2007). AHP has unique advantages when important elements of the decision are difficult to quantify or compare. AHP can be applied on various decision situations, Forman and Gass (2001) depict the following:

- Choice – The selection of one alternative from a given set of alternatives, usually where there are multiple decision criteria involved.
- Ranking – Putting a set of alternatives in order from most to least desirable
- Prioritization – Determining the relative merit of members of a set of alternatives, as opposed to selecting a single one or merely ranking them
- Resource allocation – Apportioning resources among a set of alternatives

- Benchmarking – Comparing the processes in one's own organization with those of other best-of-breed organizations
- Quality management – Dealing with the multidimensional aspects of quality and quality improvement
- Conflict resolution – Settling disputes between parties with apparently incompatible goals or positions

From the above list, in this research the AHP is used for projects selection / ranking i.e. putting a set of alternatives / projects in order from most to least desirable.

The AHP process decomposes the decision-making problem into a hierarchy of criteria and alternatives. As depicted in the following figure, the AHP process involves three levels. The top level 1 is the goal of the analysis, which in this research is to find the most suitable project(s). Level 2 is multi-criteria that consist of several criterions. The last level is the alternative / project choices.



Analytic Hierarchy Process (AHP) process decomposition into levels

First step in the AHP procedure is to make pair wise comparisons between each criterion, an example of this is provided on next page.

Each Criteria is assigned a specific importance with respect to specific scenarios (discussed letter) i.e.
Extremely Most Important,
Most Important,
Medium Important,
Less Important, and
Extremely Less Important.

If a criterion X is specified as *Extremely Most Important (scale 9)* then criterion Y mentioned under *Extremely Less Important* will get scale 1/9 with respect to criterion X. In this case, all criterion under the same importance level will be *Equally Important* among themselves. Results of the comparison (for each factors pair) were described in term of integer values from 1 (equal value) to 9 (extreme different) where higher number means the chosen factor is considered more important in greater degree than other factor being compared with. The following is an example of Pairwise Comparison Matrix:

Example – Pairwise Comparison Matrix

Pairwise Comparison Matrix

	Economic Sustair	Social Sustaina	Environment Si	Project Comme	Financial Analy	Protection fron	Completion (Su	Planning	Criticality	Operational Con	Efficiency Impro	Technical Compl
Economic Sustainability	1	1	1	3	5	5	7	7	9	9	9	9
Social Sustainability	1	1	1	3	5	5	7	7	9	9	9	9
Environment Sustainability	1	1	1	3	5	5	7	7	9	9	9	9
Project Commercial Value	1/3	1/3	1/3	1	3	3	5	5	7	7	7	7
Financial Analysis	1/5	1/5	1/5	1/3	1	1	3	3	5	5	5	5
Protection from Threats and Risks	1/5	1/5	1/5	1/3	1	1	3	3	5	5	5	5
Completion (Success)	1/7	1/7	1/7	1/5	1/3	1/3	1	1	3	3	3	3
Planning	1/7	1/7	1/7	1/5	1/3	1/3	1	1	3	3	3	3
Criticality	1/9	1/9	1/9	1/7	1/5	1/5	1/3	1/3	1	1	1	1
Operational Continuity	1/9	1/9	1/9	1/7	1/5	1/5	1/3	1/3	1	1	1	1
Efficiency Improvement	1/9	1/9	1/9	1/7	1/5	1/5	1/3	1/3	1	1	1	1
Technical Complexity (Fitness)	1/9	1/9	1/9	1/7	1/5	1/5	1/3	1/3	1	1	1	1
~~Requirement 13~~	1	1	1	1	1	1	1	1	1	1	1	1
~~Requirement 14~~	1	1	1	1	1	1	1	1	1	1	1	1
~~Requirement 15~~	1	1	1	1	1	1	1	1	1	1	1	1

The above Pairwise Comparison Matrix has been created based on the following example criteria distributions:

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Example Scenario				
Economic Sustainability Social Sustainability Environment Sustainability	Project Commercial Value	Financial Analysis Protection from Threats and Risks	Completion (Success) Planning	Criticality Operational Continuity Efficiency Improvement Technical Complexity (Fitness)

For the above criteria, following are the scales used in relation to Sustainability related factors i.e. *Economic Sustainability, Social Sustainability, and Environment Sustainability* defined as *Extremely Most Important*:

Economic Sustainability	1
Social Sustainability	1
Environment Sustainability	1
Project Commercial Value	1/3
Financial Analysis	1/5
Protection from Threats and Risks	1/5
Completion (Success)	1/7
Planning	1/7
Criticality	1/9
Operational Continuity	1/9
Efficiency Improvement	1/9
Technical Complexity (Fitness)	1/9

And, the scales in relation to *Project Commercial Value* defined as *Most Important*:

Economic Sustainability	3
Social Sustainability	3
Environment Sustainability	3
Project Commercial Value	1
Financial Analysis	1/3
Protection from Threats and Risks	1/3
Completion (Success)	1/5
Planning	1/5
Criticality	1/7
Operational Continuity	1/7
Efficiency Improvement	1/7
Technical Complexity (Fitness)	1/7

And, the scales in relation to Financial Analysis and Protection from Threats and Risks defined as Medium Important:

Economic Sustainability	5
Social Sustainability	5
Environment Sustainability	5
Project Commercial Value	3
Financial Analysis	1
Protection from Threats and Risks	1
Completion (Success)	1/3
Planning	1/3
Criticality	1/5
Operational Continuity	1/5
Efficiency Improvement	1/5
Technical Complexity (Fitness)	1/5

And, the scales in relation to *Completion (Success)* and *Planning* defined as *Less Important:*

Economic Sustainability	7
Social Sustainability	7
Environment Sustainability	7
Project Commercial Value	5
Financial Analysis	3
Protection from Threats and Risks	3
Completion (Success)	1
Planning	1
Criticality	1/3
Operational Continuity	1/3
Efficiency Improvement	1/3
Technical Complexity (Fitness)	1/3

And, the scales in relation to Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) defined as Extremely Less Important:

Economic Sustainability	9
Social Sustainability	9
Environment defined	9
Project Commercial Value	7
Financial Analysis	5
Protection from Threats and Risks	5
Completion (Success)	3
Planning	3
Criticality	1

Operational Continuity	1
Efficiency Improvement	1
Technical Complexity (Fitness)	1

The above process is repeated n x n number of times where n is the number of criterions as show above. Once the complete Matric is defined and for each case study (discussed later in this chapter), the consistency of scales assignment is also checked as shown in the following image. If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, the subjective judgment (Kwiesielewicz and Van, 2004) need to be revised. More details on the scenarios are discussed later in this chapter.

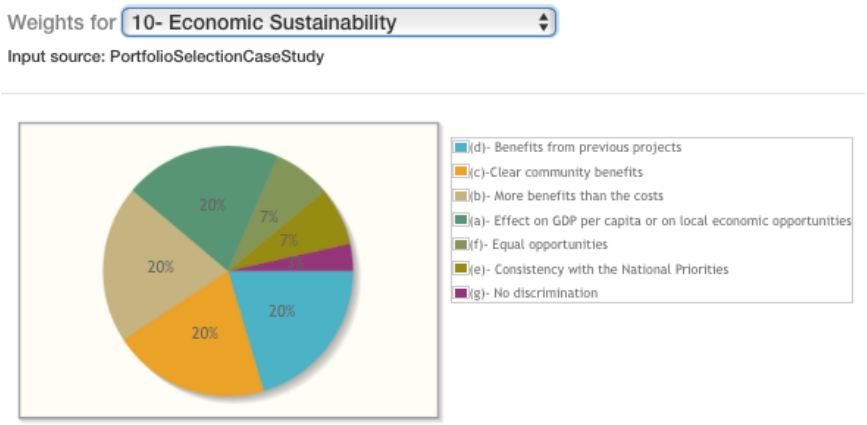
Pairwise Comparison Matrix		AHP		Consistency check
Economic Sustainability	1	0.222	22.2%	Consistency OK
Social Sustainability	2	0.222	22.2%	5%
Environment Sustainability	3	0.222	22.2%	
Project Commercial Value	4	0.091	9.1%	
Financial Analysis	5	0.050	5.0%	
Protection from Threats and Risk	6	0.050	5.0%	
Completion (Success)	7	0.031	3.1%	
Planning	8	0.031	3.1%	
Criticality	9	0.021	2.1%	
Operational Continuity	10	0.021	2.1%	
Efficiency Improvement	11	0.021	2.1%	
Technical Complexity (Fitness)	12	0.021	2.1%	

AHP pairwise matrix consistency check

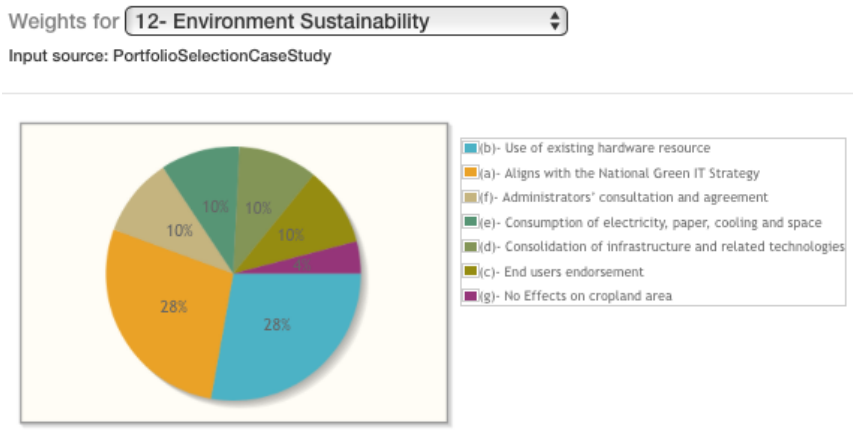
In terms of the usefulness or features of AHP, it is a very flexible and powerful tool because the scores, and therefore the final ranking, are obtained based on the pairwise relative evaluations of both the criteria and the options provided by the decision maker (Saaty and Peniwati, 2013). The computations made by the AHP are always guided by the decision maker's experience. Therefore, the AHP can thus be considered as a method/tool that can translate both qualitative and quantitative evaluations made by the decision maker into a multicriteria ranking. In addition, the AHP is simple because there is no need of building a complex expert system with the decision maker's knowledge embedded in it and various tools exist to automate the calculations. However, as done in this research, AHP does requires many evaluations, especially when there are many criteria and options. To reduce the load on decision maker / users all the project / alternatives evaluation worksheets were fully automated. Form the decision maker's point of view, every single AHP evaluation is simple as the decision maker is only required to express how criteria or alternatives compare to each other. Following depict the sub-criteria definitions by the case study organisation.

The sub-criteria for Economic Sustainability creation involved the evaluation of negative impacts of a project on the wider economy, which includes (1) Clear Community benefits, (2) Consistency with the National Priorities; (3) No discrimination to any group; (4) Provides equal opportunities; (5) More benefits than

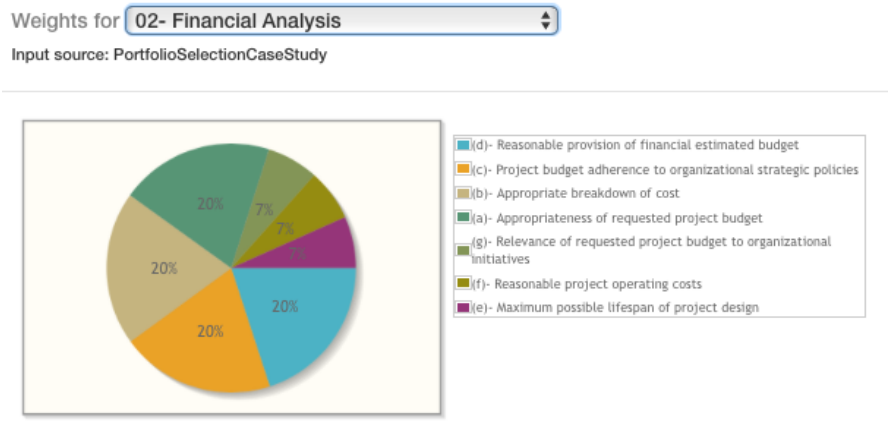
the costs; (6) No negative effect on GDP per capita or on local economic opportunities; and (7) Taking benefits from previous projects. The following image depict these sub-criteria definitions by the case study organisation.



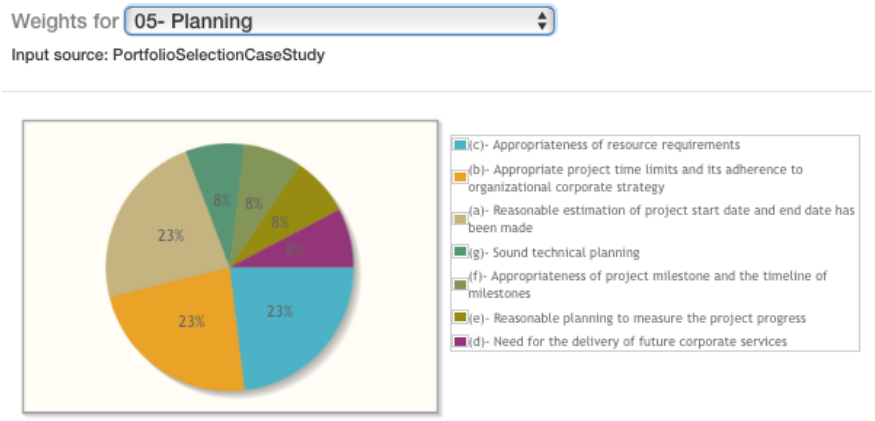
The sub-criteria for Environment Sustainability creation involved the evaluation of negative impacts of a project on environment, which includes (1) Administrators' consultation and agreement obtained on the environment aspects of the technology; (2) Aligns with the National Green IT Strategy; (3) Supports consolidation of infrastructure and related technologies; (4) Reasonable consumption of electricity, paper, cooling and space; (5) No effects on the arable permanent cropland area (i.e. land capable of being ploughed and used to grow crops; (6) End users' endorsement; and (7) Maximises the use of existing hardware resource. The following image depict these sub-criteria definitions by the case study organisation.



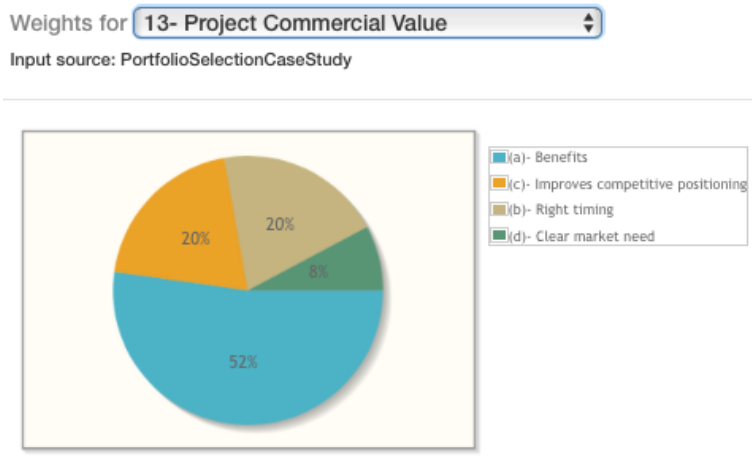
The sub-criteria for Financial Analysis creation involved the evaluation of the appropriateness of financial aspects of the project in terms of measurement and/or analysis of project financial liabilities, project lifespan, relevance to organisational initiatives, which includes (1) Appropriateness of requested project budget; (2) Appropriate breakdown of cost; (3) Maximum possible lifespan of project design; (4) Project budget adherence to organisational strategic policies; (5) Reasonable provision of financial estimated budget; (6) Reasonable project operating costs and ; (7) Relevance of requested project budget to organisational initiatives. The following image depict these sub-criteria definitions by the case study organisation.



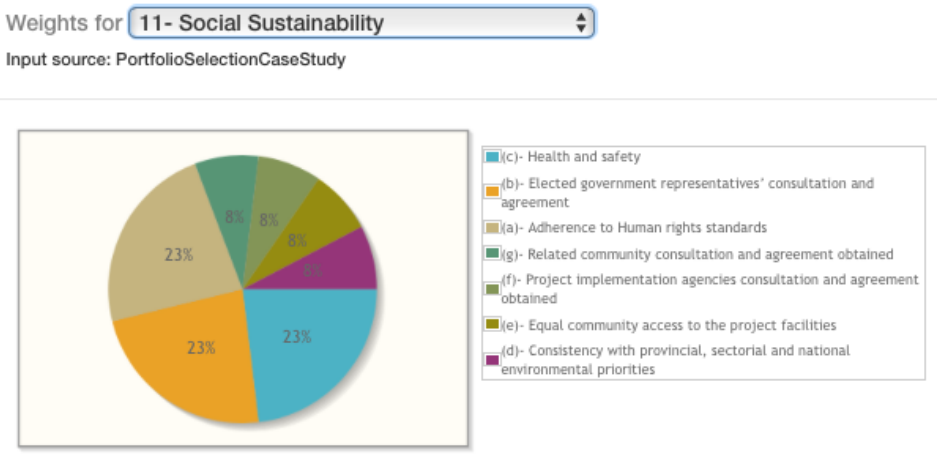
The sub-criteria for Planning creation involved the evaluation of the appropriateness of the planning aspects of the project in terms of overall planning, recourses requirements, analysis of project progress and time durations/limits, which includes (1) Appropriateness of resource requirements; (2) Reasonable estimation of project start date and end date has been made; (3) Reasonable planning to measure the project progress has been provided; (4) Appropriateness of project milestone and the timeline of milestones; (5) Sound technical planning; (6) Need for the delivery of future corporate services; and (7) Appropriate project time limits and its adherence to organisational corporate strategy. The following image depict these sub-criteria definitions by the case study organisation.



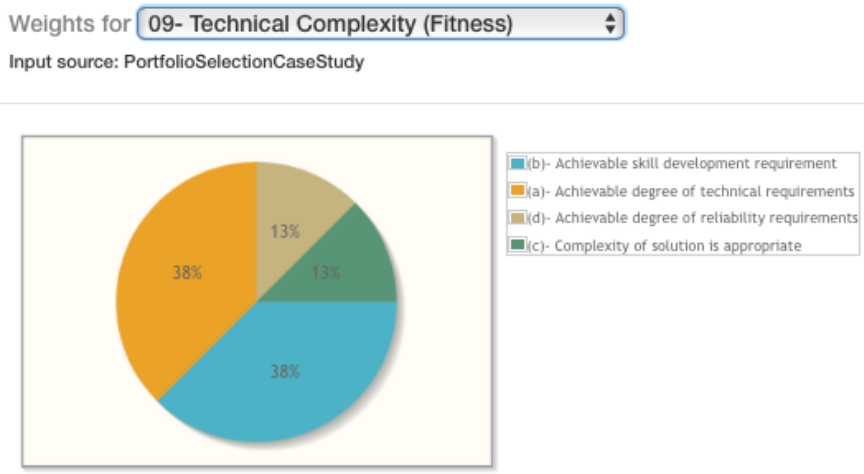
The sub-criteria for Project Commercial Value creation involved the evaluation of a project's commercial value, which includes (1) More project commercial benefits then cost; (2) Clear market need of the project/product; (3) Improves competitive positioning; and (4) Right timing. The following image depict these sub-criteria definitions by the case study organisation.



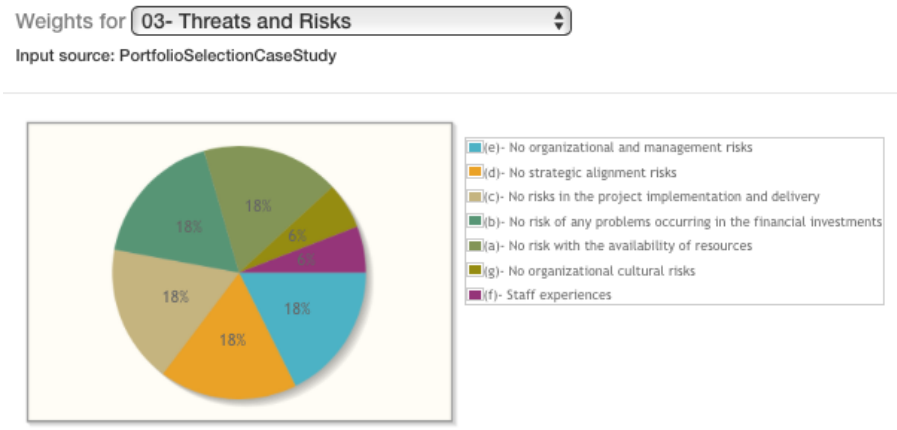
The sub-criteria for Social Sustainability creation involved the evaluation of negative impacts of project on society, which includes: (1) Adherence to Human rights standards; (2) Consistency with provincial, sectorial and national environmental priorities; (3) Elected government representatives' consultation and agreement; (4) Equal community access to the project facilities; (5) Health and safety; (6) Project implementation agencies consultation and agreement obtained; and (7) Related community consultation and agreement obtained. The following image depict these sub-criteria definitions by the case study organisation.



The sub-criteria for Technical Complexity (Fitness) creation involved the evaluation of the technical complexities and/or bottlenecks in the implementation of project, which includes (1) Complexity of solution is appropriate; (2) Achievable degree of reliability requirements; (3) Achievable degree of technical requirements; and (4) Achievable skill development requirement. The following image depict these sub-criteria definitions by the case study organisation.



Finally, the sub-criteria for *Protection from Threats and Risks* creation involved the evaluation of project threats/risks that are expected to occur during the implementation of the project, which includes (1) No risk with the availability of resources; (2) No risk of any problems occurring in the financial investments; (3) No risks in the project implementation and delivery; (4) Staff has experiences of managing or running such a project; (5)No strategic alignment risks; (6) No organisational and management risks; and (7) No organisational cultural risks. The following image depict these sub-criteria definitions by the case study organisation.



Once all the criteria / sub-criteria and AHP matrix were prepared the alternatives / projects data collection was carried out, which is explained in Chapter 5.

3.6 IT projects at Abu Dhabi Police

The Abu Dhabi Police help ensuring that Abu Dhabi remains one of the safest societies in the world, by providing high quality policing services to those who live, work and visit the Emirate. Abu Dhabi police has promised to ensure highest values by claiming that e.g. (1) we will maintain our integrity at the highest levels at all times, including our concern for human rights (2) we recognise that effective communication with our staff and stakeholders is of paramount importance to achieve our objectives; (3) we will pursue Excellence in all we do and ensure our activities are

measurably effective, efficient'. While doing so Abu Dhabi Police also develop many IT projects to equip Abu Dhabi with latest technologies and facilities. This research is an effort to ensure the selection of suitable sustainable project for development. In this regard, this thesis has considered ten mega IT projects as case studies that are briefly described as follows:

- KioskAutomatesVehicleLicensing-AdpLT2319: Abu Dhabi automates vehicle licensing with self-service machines - The Sahel self-service e-payment machines to be installed in public places. The machines will have touch-sensitive screens that allow users to renew their vehicle registration and pay fines. Customers access the service by inserting their ID card into one of the machines and choosing a vehicle from a list of all vehicles registered under their name. The system then checks records for insurance, technical inspection, vehicle records, and traffic violations. If these are satisfactory, the customer can make a payment using a credit card and obtain a receipt, registration sticker and registration card. Customers can use the machines to find out the procedure for vehicle and driver licensing services, obtain the addresses and telephone numbers of police stations in the Emirate of Abu Dhabi, file complaints, or submit suggestions. The machines also offer interactive maps, names and pharmacy rotation schedule, and weather forecast.
- ManagementSystem-AdpIT963: The proposed system is intended to provide a comprehensive database of all information related to the distribution of shifts and record the movement of staff during the time of the work between the sites by automating the creation and distribution of shifts individuals and mechanisms in the labour centres. Helping to provide true and accurate data on the numbers of forces and mechanisms in all centres.
- NationalServiceAndFederalReserveSystem-AdpIT786: Provide a range of electronic user interfaces to automate national service, federal management and backup programs to recruit candidates, follow-up working procedures of the training sessions, issuing cards, behaviour and privileges.
- SecuritySystemCompaniesV.3-AdpIT5981: Providing new mechanisms to improve the work in terms of effort, time and data integrity measures, by building new measures and add some adjustments to the system, which have been agreed upon in the prior meetings with the management of security department. This project will achieve the desired goals to provide structured infrastructure and the best features of large enterprise applications by providing maximum options for performance tuning and effectiveness, and advanced options to adjust security systems, advanced support of modern technology, maintenance, and sustainability.
- SmartLibraryWebsite-AdpIT78: The decision support office seeks to facilitate access to references and scientific research through the creation of a special electronic library website, which enables the employees of the Ministry of Interior and the public in general of Abu Dhabi Police.
- SmsSystemV1.0-AdpLT7823: SMS System - The main objective of the design and development of "management system and sending text messages version 1.0" is to develop an integrated system that provides information and data on short text messages SMS (does not include multimedia messaging MMS) that is sent to the General Command of Abu Dhabi Police level. Thus saving effort and raise the

work efficiency and facilitates the rapid liberalization process or re-send SMS messages to individuals or groups.

- StatisticsPortsSecuritySystem-AdpLT7801: Statistics ports security system - The creation of new mechanisms of action and amendments to the system to facilitate and speed up the system for different procedures, the user serve and facilitate his work, and ensure the integration of data and easy reference.
- TrafficLicencingSysV4.0-AdpTR7531: Federal Traffic and Licensing system version 4 - Improvements bugs fixes with the system according to the requirements of departments.
- VisitorReceptionSystem-AdpIT431: The proposed new mechanism will totally rely on the availability of the identity card with the references. The card will be inserted into the reader to pull the data into the system. This will ensure less manual input as the data will be emerging from the card which include name, nationality, photograph, signature and telephone and other available data.
- ConditionNotebookV2-AdpLT9765D: ConditionNotebook-SecondEdition-The provision of a new issue of conditions notebook system through the addition of the organizational structure of the Ministry of Interior to the system, including making a federal system can be used in all of the Ministry of Interior of the United Arab Emirates organizational units

In addition, Abu Dhabi Police also has various other projects such as Geographical information System. The aim of the project is to develop a smart security system to support all police activities in respect of information and knowledge. For this thesis the above mentioned 10 IT projects were considered sufficient to be used in practical evaluations as detailed in Chapter 5 of this thesis.

3.7 Reliability and Validity

According to Golafshani (2003), the reliability is defined as "the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable". As discussed above, in this research various activate were performed to collect data from ADP and existing literature, in order to gather an understanding on the consideration of various sustainability factors in PPS for the selection of IT projects, and to investigate the overall PPS process for the selection of IT projects in ADP. With the adopted research methodology (as discussed above), the results of this research would have a consistent *Mean*ing overtime.

This research has been done in collaboration with ADP; and with their strategic and IT units. Thus, the research participants in ADP had formal involvement in this research. Moreover, this has also been ensured that the participants are fully aware about the importance and needs of this research. All of this has ensured complete interest and involvement from all stakeholders in the accurate data gathering process. Therefore, the potential repeatability of this research is possible in the case of any future studies are conducted using the same research methodology.

According to Bashir et al., (2008), "validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are". As this research aimed to come up with a sustainable PPS framework of IT projects selection for Abu Dhabi Police (ADP), it was important to validate the research outcomes. Therefore, in order to increase the validity of this research, a combination of qualitative research method and case study method has been adopted. This has been done to ensure that the outcomes of both are validated and any differences are not only highlighted but also investigated. As discussed above, each of the adopted research method is applied on different population to investigate similar objectives i.e. case study method has been applied to ADP to investigate how IT projects are being currently selected in terms of sustainability and how the IT Project Portfolio Selection (PPS) is being done in ADP. And, qualitative method has been applied to gather an in-depth understanding on why and how various factors in PPS are being considered in the existing literature. Thus, the practices followed by ADP will be verified and compared by the existing practices to present a sustainable PPS framework for ADP.

3.8 Summary and Conclusions

In this chapter, the adopted methodology of this research is presented, which has enabled doing the intended research in a systemic and well-defined way. This has been done by first considering all relevant research methods in terms of their applicability and viability with respect to the aims and objectives of this research. The finally selected research methodology has been integrated in different research phases. Then, further details on the data collection methods and related processes are presented in the form of activity diagrams. This has been followed by the discussion on establishing the reliability and validity of the collected data/information. One of the major benefits achieved from the defined research methodology is that right from the beginning of this research the steps that must be carried-out to conduct this research were known. Moreover, some of the other obvious benefits that were obtained by defining this methodology include (1) a step by step progress towards achieving the defined research objectives; (2) ability of go back to a previous step if something went wrong; (3) the data analysis could only be carried out once information was received from all of the identified sources and stakeholders; and (4) ability to practically apply the resultant research findings by proposing a sustainable project portfolio selection framework, which is presented in the next Chapter 4.

Chapter 4: The Sustainable Project Portfolio Selection Framework for IT Projects (SPPS-IT)

This chapter describes the framework (process) of Sustainable Project Portfolio Selection for IT Project (SPPS-IT). The SPPS-IT contains distinct stages, where each of stages accomplish an objective and creates inputs to the next one or more stages. This chapter provides a detailed description of all SPPS-IT stages.

4.1 Introduction

This SPPS-IT separates the portfolio selection process into various distinct stages that include pre-processing, data/information flow, main SPPS-IT process stages, post-processing and document stores. In some of the stages the project portfolio managers apply various evaluation techniques for decision-making. As a case study for this research, the portfolio managers and programmers at Abu Dhabi Police (ADP) were involved to identify and implement the most suitable techniques for that organisation, which are discussed in this Chapter. However, when this S*PPS-IT* process is to be applied in other originations, their PMO office and/or project portfolio managers are free to choose the evaluation technique they find is/are the most suitable for that stage. This is to allow the decision makes to utilize a desired subset of available evaluation methodologies in easy and logical manner. Moreover, in some of the cases the users may omit a stage if that process was already completed to simplify and expedite the project portfolio selection process.

This proposed SPPS-IT process can help to select a project portfolio that maximises the criteria of interest of their organisation i.e. *inline with their cooperate strategy and sustainability strategy, and which is also suitably balanced on both quantitative and qualitative parameters they choose*. It is important to note that the proposed SPPS-IT process is based on the following important assumptions:

a. Strategic decisions concerning portfolio focus should be made in advance by the organisation.
b. A project selection framework should be flexible enough so that portfolio managers can choose in advance the particular techniques or methodologies with which they are comfortable. However, a set of techniques should be tested suitable for the selected ADP case study organisation.
c. The portfolio selection process should be organized into a number of stages to allow decision makers to move logically towards an integrated consideration of projects that are likely to be selected.
d. A common set of measures (evaluation methodology) should be chosen which could be calculated for each project under consideration in order to allow an unbiased comparison of projects during the portfolio selection process.
e. The pre-project screening stage is primarily to eliminate ineligible projects from consideration before undertaking the portfolio selection process.
f. Decision makers should be provided with means for adjusting and overriding portfolio to produce a balanced (optimal) portfolio selection.

Based on the above introduction and assumptions the proposed SPPS-IT process is presented in the next section.

4.2 The Sustainable Project Portfolio Selection Framework for IT Projects (SPPS-IT)

The overall SPSS-IT process (shown as Figure 4.1) is divided into various distinct pre-processing, data/information flow, main SPPS-IT process stages, post-processing and document stores, which are as follows:

Pre-processing stages

P1. Economic Factors

P2. Environment Factors

P3. Social Factors

P4. Specify Sustainability Constraints

P5. Generating Sustainability Criteria

P6. Functional Unit Decision Making

Generation or Collection of Data/information Stages

A. Cooperate Strategy

B. Identified Operational Constraints

C. Provides Evaluation (Actual) Constraints

D. Portfolio Balancing Policy

E. Sustainability Strategy

F. Sustainability Criteria

Main SPPS-IT Process Stages

1. Pre-Screening of Eligible Project Proposals

2. Specification of Project Proposals

3. Evaluation: Selection of Project Proposals

4. Balanced/Optimal Project Portfolio Management

Post-Processing Stages

P7. Update the project portfolio

P8. Store in database

Databases or Document Stores

D1. Project Databases

D2. Initial Rejected Projects (Database)

D3. D3. Spreadsheet (Database)

D4. Existing (Running) Projects Database

D5. Selected Projects for Development (Database)

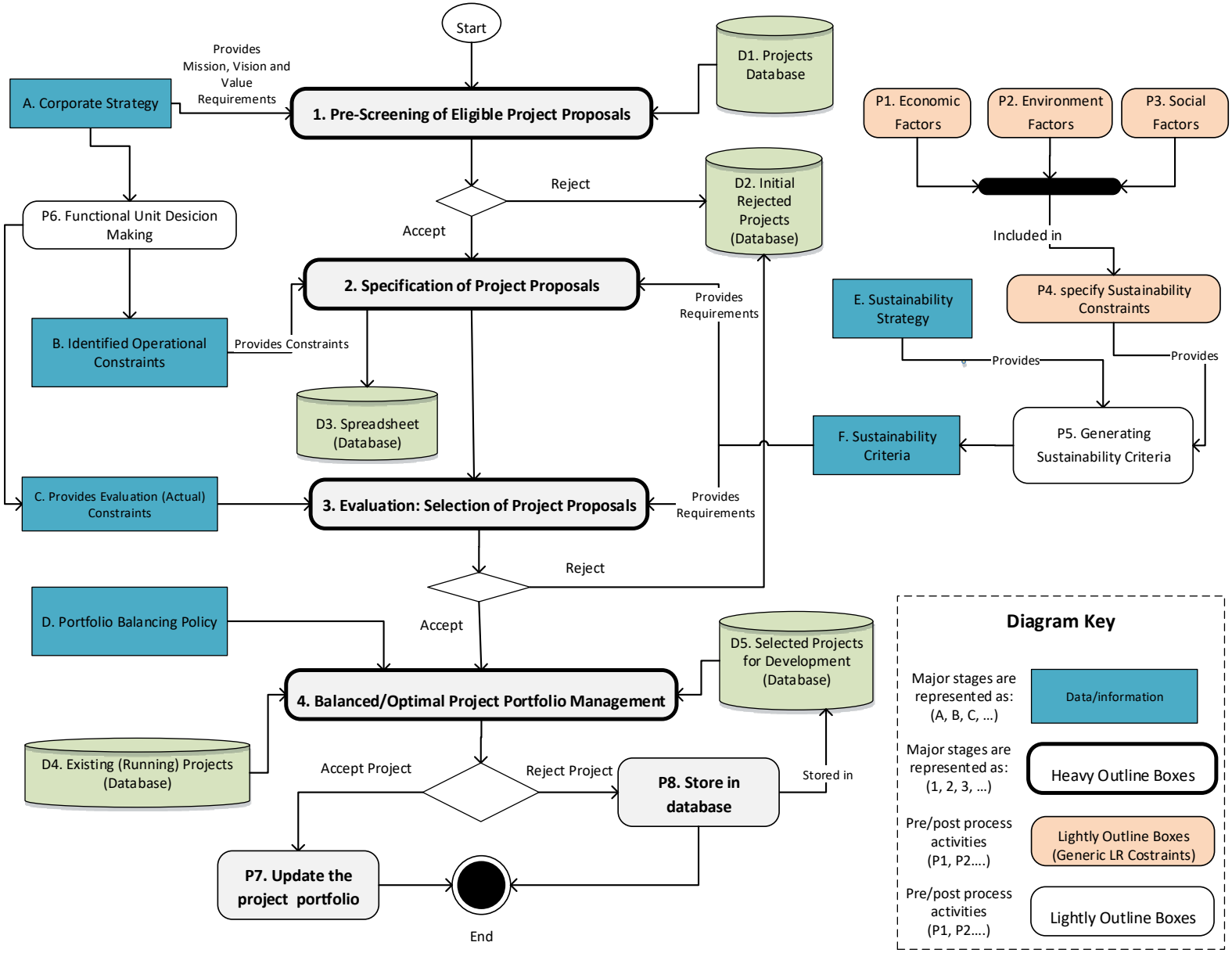


Figure 4.1: The Process of Sustainable Project Portfolio Selection for IT Projects (SPPS-IT).

In the next sections details of all the SPPS-IT stages are discussed.

4.3 The Pre-Processing Stages of SPPS-IT

This section describes the details of pre-processing stages of SPPS-IT as shown in Figure 4.1.

4.3.1 P1. Economic Factors

Sustainability strategy defines the economic, social, and environment sustainability constraints that need to be evaluated during the project portfolio selection process. There are separate economic, social, and environment requirements for safeguarding of asserts for future generations. Economic viability of a project refers to economic and financial profitability of project at the national level. The economic dimension of sustainability in project selection is to ensure that the project considered economic implications so that negative impacts on wider economy are either avoided or mitigated during the life of the project.

Following are the economic considerations for sustainable PPS that are relevant to the selection of IT projects in ADP and commissioned from the literature that includes (Khalili-Damghani et. al., 2013), (Ghasemzadeh, 2000), (Archer, 1999), (Abbassi, 2014) and (Heising, 2012):

National Priorities	The project is consistent with national priorities
Crate Opportunities	The solutions are high quality and provide repeated future opportunities to economy
Equal Access	Almost everyone in the community have access to the project facilities i.e. 'rich', ‘middle’ and 'poor' income class
Equal Benefits	The expected benefits are not discriminated only towards one class
Clear Community Benefits	The project provides clear benefits in terms of increase of income OR higher standard of living OR higher productivity
Building on Exiting Projects	The project is realistically taking benefit from the development of all related previous projects
No Negative Effects	The project does not have any negative effect on GDP per capita and also is not putting any negative effect on local economic opportunities for the community

4.3.2 P2. Environment Factors

Environmental sustainability refers to the long-term maintenance of valued environmental resources in an evolving human context. Environmental dimension of sustainability in project selection is to ensure that project has considered environmental implications so that negative impacts on environment are either avoided or mitigated during the life of the project. Moreover, environmental sustainability relates to project induced environmental impacts - both positive and negative. If negative impacts are foreseen and no mitigation measures are planned,

then ultimately the project may yield benefits at a reduced rate or worse still and depending on the extent of environmental costs, such negative impacts may in fact contribute to the net losses to the economy.

In order to improve sustainability, the amount of resources, waste and emissions must be reduced. This definition encourages implementation of energy efficiency technologies, sustainable travel, waste minimization and recycling. Moreover, to train and educate staff with regards to sustainable best practice, particularly in the areas of resource efficiency, recycling, energy efficiency, renewable energy production, conservation of natural resources, sustainable travel and welfare. The scope of this strategy addresses each of these areas. Following are the environmental considerations for sustainable PPS that are relevant to the selection of IT projects in ADP and commissioned from the literature that includes (Khalili-Damghani et. al., 2013), (Ghasemzadeh, 2000), (Archer, 1999), (Abbassi, 2014) and (Heising, 2012):

Compliance to Legal Requirements	The identification and then strict compliance with the letter and intent of all relevant legal and other requirements. Such as alignment with the National/ Government's Green IT Strategy
Efficient use of Existing Resources	The efficient use of materials and resources e.g. use of available hardware
Minimise Consumption	Wherever practical and possible minimize resources usage e.g. minimise energy usage, recycle materials etc.
Integrated Infrastructure	Consolidation of infrastructure and related technologies or the use of centralized deployment architecture and designs.
End Users Consultation	End users' endorsement to the project
Administrators' Consultation	Administrators' consultation and agreement on considering the environment aspects of the technology components
No Adverse Effects	Evaluation of all other environmental impacts e.g. global warming, ozone depletion, etc.

4.3.3 P3. Social Factors

Social dimension of sustainability in project selection is to ensure that project maintains social stability - i.e., measuring that has the project considered social implications so that negative impacts on society are either avoided or mitigated during the life of the project. Moreover, it is also to consider issues relate to the level and degree of acceptability of a project to the community, the local representatives, the executing agency etc. Weak acceptability by anyone or more of these parties has the risk of compromising long-term sustainability of a project.

In order to improve sustainability, it is must to reduce or eliminate its negative social implications. Moreover, the staff needs to be trained and educated with regards to sustainable best practice, particularly in the social dimension. Following is the list

of social considerations for sustainable PPS that are relevant to the selection of IT projects in ADP and commissioned from the literature that includes (Khalili-Damghani et. al., 2013), (Ghasemzadeh, 2000), (Archer, 1999), (Abbassi, 2014) and (Heising, 2012):

Community Benefits	Community access and benefits of IT projects
Social Priorities	Looking after provincial, sectorial priorities and national environmental priorities.
Community Agreement	Community consultation on project as beneficial and disadvantage/discriminating to any particular group
No Discrimination	Does not disadvantage or discriminate any particular group in the related community
Govt. Consultation	Consultation and agreement of local elected representatives /leaders
Health & Safety Standards	Consideration of issues related to the health & safety standards that protect all who are engaged in or affected by the project
Human Rights Standards	Maintaining human rights standards e.g. no risks of child labour or measures taken towards elimination of child labour

4.3.4 P4. Specify Sustainability Constraints

The outcome of three pre-process activities i.e. *P1 Economic Factors*, *P2 Environment Factors* and *P3 Social Factors* are combined to in the specification of *Sustainability Constraints (P4)* as shown in the following table:

Combining Sustainability Considerations		
Economic	Environment	Social
○ National Priorities	○ Compliance to Legal Requirements	○ Community Benefits
○ Crate Opportunities	○ Efficient use of Existing Resources	○ Social Priorities
○ Equal Access	○ Minimise Consumption	○ Community Agreement
○ Equal Benefits	○ Integrated Infrastructure	○ No Discrimination
○ Clear Community Benefits	○ End Users Consultation	○ Govt. Consultation
○ Building on Exiting Projects	○ Administrators' Consultation	○ Health & Safety Standards
○ No Negative Effects	○ No Adverse Effects	○ Human Rights Standards

Moreover, it has been investigated that for the application of ADP sustainably evaluation process to include a *"Sustainability Criteria"* for project's evaluation that provides the data on sustainability factors for that project. The overall criteria is commissioned and integrated from ADP sustainability policy and from the literature that includes (Khalili-Damghani et. al., 2013), (Ghasemzadeh, 2000), (Khalili-Damghani, 2013a), (Khalili-Damghani, 2013b), (Archer, 1999), (Abbassi, 2014) and (Heising, 2012). It is also used during the project evaluation stages in order to

support/fund the most sustainable IT projects. These criteria have been confirmed as suitable for the case study organisation. However, for other organisations more requirements can be added or the exiting ones can be modified. This change will have no effect on the core applicability of the proposed framework.

4.3.5 P5. Generating Sustainability Criteria

The ADP sustainability strategy is having multi-dimensional attributes towards environment, social and economic sustainability. In order to enhance ADP's project sustainability, a rigorous sustainability analysis is needed at the time of formulation/evaluation of a project proposal. It is expected that such an analysis will also assist in incorporating the elements of sustainability, right at the proposal and design stage of a project. The pre-process activity *P5 Generating Sustainability Criteria* takes input from *Sustainability Strategy (shown as E in the Figure 4.1)* and *P4. Specify Sustainability Constraints*. These criteria (i.e. presented later in this section) will be used to perform sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of the sustainably factors that are likely to impact, either positively or negatively.

The resultant generated sustainability criteria present a tool for checking the aspects of environmental, social and economic sustainability, at the time of proposing of a project. These criteria include several environmental, social and economic analyses, which are important and should be undertaken to ensure incorporation of sustainability considerations during the preparation and the design stages of a project. Moreover, in these criteria some of the sustainability factors are related to the "acceptability" issues, which relate to the level and degree of acceptability of a project to the community, the local MP, the project executing agency e.g. government etc. It could be expected that weak or no acceptability by anyone or more of these parties has the risk of compromising long term sustainability of a project and therefore should be given importance.

Economic Sustainability Criteria: To investigate the extent to which the project has considered economic implications so that negative impacts on the wider economy are either avoided or mitigated.

1. The proposed project is undoubtedly and unambiguously consistent with the National Priorities.
2. Project benefits are greater than the costs OR the project is expected to provide repeated future opportunities to the economy.
3. The people who are going to have access to the project facilities will equally belong to the 'rich', middle income' or 'poor' income classes.
4. The project's expected benefits are not discriminated only towards 'rich' or 'middle' income class and 'poor' economic class will equally benefit from the project.
5. The clear community benefits from this project are in terms of increase of income OR higher standard of living OR higher productivity.
6. The project is realistically taking benefit from the development of all related previous projects.
7. The project does not have any negative effect on GDP per capita and is not putting any negative effect on local economic

opportunities for the community.

Environmental Sustainability Criteria: To investigate the extent to which the project has considered environmental implications so that negative impacts on environment are either avoided or mitigated?

1. Project proposal is aligned with the National/Government's Green IT Strategy.
2. The project uses existing organisational hardware resource/equipment.
3. Measures have been considered on consuming less electricity, less paper, less consumable, less cooling and space requirements.
4. Consolidations of infrastructure and related technologies have been considered OR the use of centralized deployment architecture design has been considered.
5. End users have endorsed the project in terms of reduction of printing, promotion of paper free environment, increased digitization of document and increase of workflow automation (if relevant).
6. Administrators have been consulted and agreement obtained on considering the environment aspects of the technology components e.g. raw material usage and emissions (air, water, land) and any other environmental impacts (global warming, ozone depletion, acidification, human toxicity, eco-toxicity, summer smog, eutrophication).
7. It has been confirmed that the project does not have any adverse effect on the arable permanent cropland area (land capable of being ploughed and used to grow crops), or if it has then environmental considerations and effects of the project have been properly documented and communicated to the department.

Social Sustainability Criteria: To investigate the extent to which the project has considered social implications so that negative impacts on society are either avoided or mitigated

1. A large proportion of the community will have access to the project facilities and/or will benefit from it.
2. The proposed project is consistent with provincial, sectorial and national environmental priorities.
3. Related community has been consulted and they do consider this project as beneficial and acceptable in terms of both process and product.
4. The project does not disadvantage or discriminate any particular group in the related community; and in this regard, local elected representatives and community leaders have been consulted.
5. Related project implementation agencies have been consulted and an agreement is obtained.
6. The project passes the health and safety (employees, contractors, customers, citizens) criteria without any doubt and/or requirement of more information.
7. The project will be maintaining human rights standards; and has it been confirmed that there are no risks of child labour in this

project, Or if there are risks of child labour then proper measures been taken to contribute to the elimination of child labour.

4.3.6 P6. Functional Unit Decision Making

The functional decision making unit is a collection or team of individuals who participate in project decision process. They act on the guidelines provided by their organisational cooperate strategy. The *Functional Unit Decision Making* is the first pre-process activity of SPPS-IT in which project evaluation and operational constrains are defined based on the organisational cooperate strategy.

4.4 Generation or Collection of Data/information Stages

This section presents details of all the data and/or information stages of SPPS-IT.

4.4.1 A. Cooperate Strategy

An organisation's Corporate Strategy provides a base and high-level guidelines to the portfolio selection process. The Corporate Strategy provides *Mission, Vision and Value Requirements* for the pre-screening of *Eligible Project Proposals* in the proposed SPPS-IT process. These guidelines are used for the determination of strategic focus and setting resource constraints that are to be utilized in the portfolio selection. The decision of strategic focus is to be carried out at higher managerial levels, because it very much involves cooperate strategic direction.

4.4.2 B. Identified Operational Constraints

This provides detailed guidelines (about constraints and requirements) to both "*Specification of the Project Proposals (main stage 2)"* and "*main Evaluation Selection of Project Proposals (main stage 3)"* in the SPPS-IT process. Here the Operational Constraints / Requirements are related to Project Planning (PP), Threats and Risks (TR) and Financial Analysis (FA), which are described as follows:

Project Planning (PP): To investigate the extent to which the project is well planned.

1. Reasonable technical planning
2. Reasonable resource requirements
3. Reasonable planning to measure the project progress
4. Reasonable estimation of project start date and end date
5. The project milestone and the timeline of milestones are realistically
6. The project's criticality for delivery of future corporate services of the organisation and/or to provide important decision-support aid to the organisation
7. The project can be completed within the maximum time limit provided by the organisational corporate strategy

Threats and Risks (TR): To investigate the extent to which the project has measured the threats/risks that are expected to occur during the implementation of the project and their mitigation strategy

1. Current staff has previous and common experiences of managing or running such a project
2. The risks from strategic alignment issues and plan for mitigation
3. The risks related to financial investments and plan for mitigation

4. The risks of an organisational and management nature and plan for mitigation
5. The organisational cultural and climate risks and plan for mitigation
6. The risks related to the delay (in time scale) in the delivery and implementation of the project and plan for mitigation
7. Current staff has adequate experience for operating such a project post-delivery or other outside resources have been realistically identified

Financial Analysis (FA): To investigate the extent to which the project has reliable financial analysis.

1. A financial estimated budget
2. The total requested project budget is realistic
3. The project budget is related to one of more organisational initiatives
4. A realistic and micro level breakdown of project cost has been provided
5. The requested project budget is (and expected to remain) within the limits defined by the organisational strategic policies
6. Reasonable project operating costs
7. The design of project (including hardware, software and installations) is justifiably maximizing its lifespan with a minimum level of cost for care and maintenance

4.4.3 C. Provides Evaluation (Actual) Constraints

This provides evaluation constraints to the 3rd main stage of SPPS-IT i.e. *Evaluation of Projects Proposals*. Using these constraints interactions among the various projects are considered, including interdependencies, division of resources, planning etc. The main constraints that will be evaluated here include Criticality, Project Success, Benefits, Efficiency Improvement, Risks, Operational Continuity, Financial Value, Commercial Value, and Technical Complexity. Some of the above main constraints also involve sub-constraints, which are detailed in the later section of this document.

Moreover, a scoring *Mode*l was needed based on project evaluation questions to calculate the scores of each project. This has been achieved by working the portfolio managers at ADP through meetings and focused group session. More details and process of calculating scores and preforming balance is explained in the later sections of this document.

4.4.4 D. Portfolio Balancing Policy

The portfolio policy establishes the mechanism to achieve a balanced portfolio of projects. The portfolio balancing policy is an important input to the SPPS-IT, which helps in achieving a portfolio that meets both the strategic and sustainability objectives of the organisation optimally. Therefore, while applying this policy all relevant evaluation information of the projects and evaluation factors scoring /ranking must be made available to allow decision makers to evaluate the portfolio and make informed decisions. Based on the portfolio policy, a portfolio of projects could be adjusted based on several factors or balancing areas. Moreover, according to ADP

Portfolio Balancing Policy the following two policy wordings should be observed while SPPS-IT balancing:

g. While performing projects evaluation the portfolio managers must have the option to select any suitable evaluation technique as per their comfort, availability of data, tools and skills.
h. By default, all of the project evaluation factors should have equal weightages. However, the PMO office should aim to achieve a portfolio that meets both the strategic and sustainability objectives of the organisation optimally, but with the possibility for final judgmental adjustments by the SPPS-IT decision committee appointed by the PMO.

In the research, through rigorous literature review and by working with ADP's PMO office, various balancing factors have been identified e.g. social, economic and environment sustainability considerations, organisational corporate strategy requirements, risks, project planning etc. to support portfolio balancing.

4.4.5 E. Sustainability Strategy

Sustainability is to achieve the safeguarding of asserts for future generations. Sustainability strategy is usually a part of *Corporate Strategy*; and therefore, may also be called as *Corporate Sustainability Strategy*. Having, refining or building a new corporate sustainability strategy is a planning stage that provides base guidelines/requirements for generating the *Sustainability Criteria (shown as P5 and F in Figure 4.1)* to be used by both *Specification of the Project Proposals (main stage 2 in Figure 4.1)* and the *Evaluation Selection of Project Proposals (main Stage 3 in Figure 4.1).*

4.4.6 F. Sustainability Criteria

The resultant generated Sustainability Criteria (shown as F in Figure 4.1) presents a tool for checking the aspects of environmental, social and economic sustainability, at the time of proposing of a project. These criteria include a member of environmental, social and economic analyses, which are important and should be undertaken to ensure incorporation of sustainability considerations during the preparation and the design stage of a project. Here the sustainability criteria (or requirements) are related to:

a. Environmental Sustainability Requirements: to establish the extent to which the project has considered environmental implications so that negative impacts on environment are either avoided or mitigated;
b. Social Sustainability Requirements: to establish the extent to which the project has considered social implications so that negative impacts on society are either avoided or mitigated; and
c. Economic Sustainability Requirements: to establish the extent to which the project has considered economic implications so that negative impacts on the wider economy are either avoided or mitigated.

4.5 The Main SPPS-IT Process Stages

This section presents the details of all the main stages of SPPS-IT.

4.5.1 1. Pre-Screening of Eligible Project Proposals

As discussed above, an organisational corporate strategy provides a base and high-level guidelines to the portfolio selection process. In this stage of *"Pre-Screening of Eligible Project Proposals"*; by making use of organisational *Corporate Strategy*, *Pre-Screening of Eligible Project Proposals* is carried out. Here, the corporate strategy provides *Mission*, *Vision* and *Value* Requirements for the pre-screening of eligible project proposals. This pre-screening activity ensures that any project being considered for the portfolio its strategic focus should match to the cooperate strategy. Pre-screening is usually an essential requirement before the project goes in to portfolio selection process. If a project is accepted then it is moved to the next stage of the PPS process; and if rejected, then it is move to the *Initial Rejected Projects Database* (shown as D2 in the figure).

This pre-screening of eligible project proposals is carried out to investigate the extent to which the project has addressed the strategic priorities of the organisation, which may include (and depending on an organisational corporate strategy):

1. Support to the core strategy / strategic priorities of the organisation
2. Alignment with the organisational mission, vision, and values
3. Potential for growth or innovative progress
4. Future integration with other projects
5. Employees learning and growth
6. Matches corporate culture (e.g. adopting change and re-organisation)
7. Meets shareholder interests

4.5.2 2. Specification of Project Proposals

The projects accepted in the previous stage of *Pre-Screening of Eligible Project Proposals* are further specified (scrutinized) in this stage i.e. *"Specification of Project Proposals".* This is an important stage of the project portfolio selection process and the portfolio managers must avoid setting wrong or haphazard thresholds that may cause elimination of projects that may otherwise be very important for the organisation. This stages uses two inputs to carry out the tasks i.e. (1) *Operation Constraints* that are obtained from *Functional Unit Decision Making*; (2) *Sustainability Criteria Requirements* obtained from *Organisational Sustainability Strategy* and *Sustainability (economic, social, and environment) Constraints*.

The overall outcome is achieved by going through various areas of evaluation i.e.

- **a.** Project Planning (PP)- to determine the scale of planning;
- **b.** Threats and Risks (TR): to determine the project threats/risks that are expected to occur during the implementation of the project and their mitigation strategy; and
- **c.** Financial Analysis (FA)

And, three are related to *Sustainability Requirements* i.e.

- **d.** Environmental Sustainability Requirements – to determine if the project has considered environmental implications so that negative impacts on environment are either avoided or mitigated;
- **e.** Social Sustainability Requirements - to determine if the project has considered social implications so that negative impacts on society are either avoided or mitigated; and

f. Economic Sustainability Requirements - to determine if the project has considered economic implications so that negative impacts on the wider economy are either avoided or mitigated.

Each of the above areas has seven evaluation items associated to them, so in total 49 Project Proposal scrutinizing items are specified and evaluated in the Specification of Project Proposals stage. The overall 49 Project Proposal scrutinizing items have been confirmed as suitable for the case study organisation (i.e. ADP). However, for other organisations more requirements may be added or the exiting ones can be modified. This change will have no effect on the core applicability of the proposed sustainable PPS process. All project proposals that go through this stage are then stored to a Spreadsheet Projects Database.

The scrutinizing items for all seven areas of evaluation are presented in Appendix 1**.** The project proposals are evaluated as per the following scales for each of the areas:

AS – Agree strongly; Scale = 4
A – Agree; Scale = 3
N – Neither agree nor disagree; Scale = 2
D – Disagree; Scale = 1
DS – Disagree strongly; Scale = 0

The obtained evaluation outcomes are further combined with (0-1) *weights*, The use of 0-1 weights; also referred as zero–one integer linear programming 0–1 ILP *Mode*l (Archar et. al. 2000), maximises the overall objective of the portfolio, while satisfying existing constraints. In this research, the *weights* have been obtained during the focused groups workshops at ADP. Further details and evaluations are presented in Chapter 4 of this thesis.

For further evaluation, various other factors have been gathered after conducting detailed literature survey and having discussions with PMO office at ADP. The technique used to carry out evaluation of the other factors is Multi Criteria Decision Making using Pairwise comparison or Analytic Hierarchy Process (AHP) techniques, which has been selected after consultation with the case study organisation (ADP). These are discussed in next sections.

4.5.3 3. Evaluation: Selection of Project Proposals

This is the main evaluation stage where all the new selected projects and in-progress projects are evaluated based on the evaluation constraints provided by both of the *Operational Constraints (B)* and *Sustainability Criteria (F)* pre-stages (as discussed in the above section). Here, the common set of parameters that were estimated for each project in the previous stage help to balance the portfolio selection. In the literature, various potential methodologies already exist such as *manually applied criteria, check lists, scoring Models, multi criteria decision making* and other *ad hoc evaluation methods*. The most used techniques to perform this stage are *scoring Models*, *pairwise comparison* and *portfolio matrices*, because they allow users to consider a broad range of quantitative and qualitative characteristics as well as multiple objectives. However, it may vary from organisations to organisations that how they want to practically perform the process of this stage. Moreover, usually the portfolio managers have the option to select a suitable technique as per their comfort, availability of data, tools and skills.

Evaluation of values for each of the following factors (and as shown in Figure 4.2) are calculated using *Pairwise Comparison* or *Analytic Hierarchy Process (AHP)* by the PMO office:

4.5.4 The project attributes include:

a. Cost
b. Net Present Value (NPV)
c. Internal rate of return (IRR)
d. Return on investment (ROI)

4.5.5 Main evaluation stage criteria / sub-criteria description:

1. Completion (Success)

e. The project can be successfully completed as per the project proposal

2. Criticality:

f. The development of this project is crucial

3. Economic Sustainability

g. No negative impacts of this project on the wider economy, or the impacts are either avoided or mitigated

i. Clear Community benefits
ii. Consistency with the National Priorities
iii. No discrimination to any group
iv. Provides equal opportunities
v. More benefits than the costs
vi. No negative effect on GDP per capita or on local economic opportunities
vii. Taking benefits from previous projects

4. Efficiency Improvement

h. The development of this project is required for the improvement of organisational efficiency.

5. Environment Sustainability

No negative impacts of this project on environment, or the impacts are either avoided or mitigated.

i. Administrators' consultation and agreement obtained on the environment aspects of the technology
ii. Aligns with the National Green IT Strategy
iii. Supports consolidation of infrastructure and related technologies
iv. Reasonable consumption of electricity, paper, cooling and space
v. No effects on the arable permanent cropland area (i.e. land capable of being ploughed and used to grow crops
vi. End users' endorsement
vii. Maximises the use of existing hardware resource

6. Financial Analysis

Appropriateness of financial aspects of the project in terms of measurement and/or analysis of project financial liabilities, project lifespan, relevance to organisational initiatives

i. Appropriateness of requested project budget
ii. Appropriate breakdown of cost
iii. Maximum possible lifespan of project design
iv. Project budget adherence to organisational strategic policies
v. Reasonable provision of financial estimated budget

vi. Reasonable project operating costs
vii. Relevance of requested project budget to organisational initiatives

7. Operational Continuity

The development of this project is required for the continuity of organisation functions/operations.

8. Planning

Appropriateness of the planning aspects of the project in terms of overall planning, recourses requirements, analysis of project progress and time durations/limits.

i. Appropriateness of resource requirements
ii. Reasonable estimation of project start date and end date has been made
iii. Reasonable planning to measure the project progress has been provided
iv. Appropriateness of project milestone and the timeline of milestones
v. Sound technical planning
vi. Need for the delivery of future corporate services
vii. Appropriate project time limits and its adherence to organisational corporate strategy

9. Project Commercial Value

The project has a commercial value

i. More project commercial benefits then cost
ii. Clear market need of the project/product
iii. Improves competitive positioning
iv. Right timing

10. Social Sustainability

No negative impacts on society, or the impacts are either avoided or mitigated.

i. Adherence to Human rights standards
ii. Consistency with provincial, sectorial and national environmental priorities
iii. Elected government representatives' consultation and agreement
iv. Equal community access to the project facilities
v. Health and safety
vi. Project implementation agencies consultation and agreement obtained
vii. Related community consultation and agreement obtained

11. Technical Complexity (Fitness)

The project is technical fit i.e. not having any technical complexities and/or bottlenecks

i. Complexity of solution is appropriate
ii. Achievable degree of reliability requirements
iii. Achievable degree of technical requirements
iv. Achievable skill development requirement

12. Protection from Threats and Risks

No project threats/risks are expected to occur during the implementation of the project, or the impacts are either avoided or mitigated.

i. No risk with the availability of resources
ii. No risk of any problems occurring in the financial investments
iii. No risks in the project implementation and delivery
iv. Staff has experiences of managing or running such a project
v. No strategic alignment risks
vi. No organisational and management risks
vii. No organisational cultural risks

It is important to note here that as per the literature the decision makers should be given the choice to select their own method for evaluation. In this regard, when these were discussed with ADP experts they mentioned that the decision makers usually use pairwise comparison, AHP and expert opinions to make these decisions.

Moreover, the values for Social, Environment and Economic Sustainability are obtained by the details "PPS" procedure adopted in this research and explained earlier in previous sections. Moreover, the *Project Success* and *Benefit* probabilities are given by the PMO office experts based on the project data and their expert knowledge.

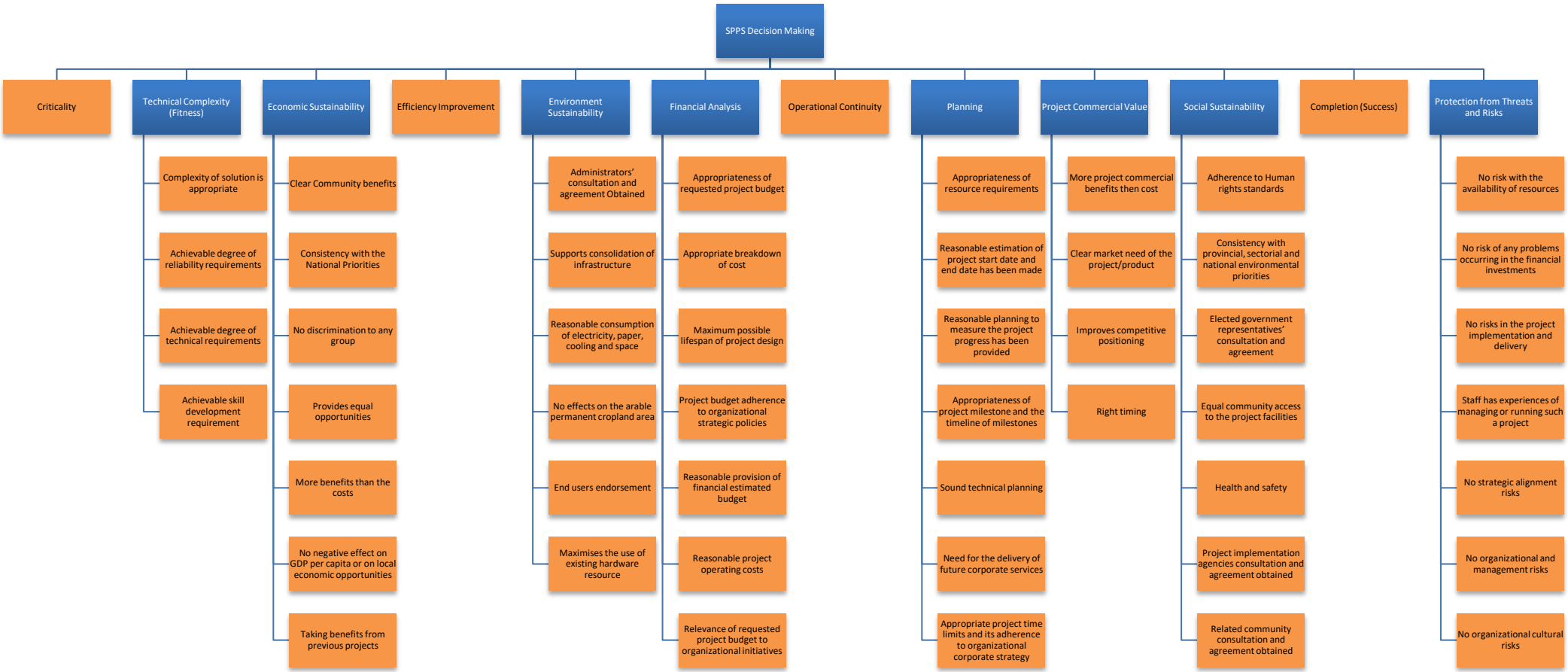


Figure 4.2: The main evaluation stage / balancing criteria and sub-criteria

4.5.6 - 4. Balanced/Optimal Project Portfolio Management

In this last main stage of SPPS-IT process, the aim is to achieve an optimal portfolio where interactions among the various projects are considered, including sustainability, priority, division of resources, planning, project risks, finances etc. The main input to this stage is the organisation's *Portfolio Balancing Policy*.

In this stage, the portfolio can be adjusted based on a number of factors or balancing areas as described in the portfolio balancing policy. The portfolio balancing policy is applied to the pre-decided common set of evaluation parameters in order to achieve the balancing of the portfolio.

Because of this Optimal Project Portfolio Management stage, the aim is to achieve a portfolio that meets both the strategic and sustainability objectives of the organisation optimally, but with the possibility for final judgmental adjustments by the decision maker, which are otherwise difficult to anticipate and include in a *Mode*l. Therefore, at this stage all relevant evaluation information and factors scoring /ranking must be made available to allow decision makers to evaluate and balance the portfolio and make informed decisions. In order to achieve this optimisation, *weightages* both for the main and sub-criteria are used. The *sub-criteria weightages* allow decision makers to adjust the priority of each sub-criterion or by default take all of them as equal. Similarly, the *main criteria weightages* allow decision makers to adjust the priority of between 12 main factors.

By default, all of the criteria have equal weightages. In the separate excel sheet all a sample scoring is presented along with the scoring outcome in the last four columns.

4.6 Post Process Stages

This section presents details of all of the post process stages of SPPS-IT.

4.6.1 P7. Update the project portfolio

If a project is accepted, then the project details are recorded in the project portfolio database along with all the calculated parameters for future reference. Project database is a repository that holds all information of the running projects for reusability and tracking purposes.

4.6.2 P8. Store in database

The rejected projects from the main stage 4 of *Optimal Project Portfolio* are stored in the *Project Database* for Development. This may include new as well as previously running project that may have been temporally suspended.

4.7 Database or Document Stores

This section presents details of all the database or document stores of SPPS-IT.

4.7.1 D1. Project Databases

This contains all the project proposals submitted for approval and development. The project database is an input to the first main stage of SPPS-IT i.e. *Pre-screening of Eligible Projects.*

4.7.2 D2. Initial Rejected Projects (Database)

The projects that are rejected in the first main stage of SPPS-IT i.e. pre-screening of eligible projects are stored in the *Initial Rejected Projects* database.

4.7.3 D3. Spreadsheet (Database)

All the accepted projects from the first main stage of SPPS-IT i.e. pre-screening of eligible projects are specified and evaluated based on the operational constraints and sustainability criteria. These projects are also stored in the *Spreadsheet* database.

4.7.4 D4. Existing (Running) Projects Database

In this last main stage of SPPS-IT, all the new as well as existing running projects are considered to achieve a balanced or optimal portfolio selection where interactions among the various projects are also considered. The *Existing (running) Projects* database provides detailed description of all the projects under development.

4.7.5 D5. Selected Projects for Development (Database)

All projects rejected in the final stage of SPPS-IT are stored in the selected projects for development database. These projects may then be reconsidered in the next phase of evaluation.

4.8 Comparison between Sustainable PPS and Archer's PPS Process

In chapter 2 and as part of achieving the objective 1 of this research, a shortlisting of nine candidate PPS frameworks was carried out. This was followed by the selection of an integrated framework for project portfolio selection presented by (Archer et. al., 1999) as an appropriate model to customise, extend and also to include sustainability for the selection of IT projects. In this section a comparison between Archer's et. al. PPS Framework (Figure A) and the newly proposed sustainable project portfolio selection framework (SPPS) is presented.

In this table first a comparison between pre-processing stages is presented:

Stage ID and Stage Name.	***SPPS***	***Archer PPS***
Pre-Stage P1 Project Proposals	This is the collection of all of the projects to be considered in a project portfolio selection process.	
Pre-Stage P2 Corporate Strategy	Having a corporate strategy is a pre-process activity that provides a base and high-level guidelines to the portfolio selection process. Moreover, the corporate strategy provides mission, vision and value requirements for the pre-screening of eligible project proposals.	
	Corporate strategy also guides in functional unit decision-making and eventually in generating operation constraints for the later stages of portfolio selection process.	Corporate strategy provides guidance for resource allocation, which is used for setting resource constraints while balancing portfolio selection. The decision of strategic focus is carried out at higher managerial levels.

Stage ID and Stage Name.	***SPPS***	***Archer PPS***
Pre-Stage P3 Functional Decision Making	Corporate strategy sets out guidelines in order to define projects operational constraints.	*Not Available*
Pre-Stage P4 Operational Constraints	Provides detailed guidelines (constraints and requirements) to both Specification of the Project Proposals (Stage 2) and main Evaluation Selection of Project Proposals (Stage3). Here the Operational Constraints / Requirements are related to: Project Planning (PP); Threats and Risks (TR): Describe project threats/risks that are expected to occur during the implementation of the project and their mitigation strategy; and (4) Financial Analysis (FA).	*Not Available*
Pre-Stage P5 Formulate Sustainability Strategy	Sustainability Strategy is part of Corporate Strategy; and therefore, may also be called as Corporate Sustainability Strategy. Having, refining or building a new Corporate Sustainability Strategy is a planning stage that provides base guidelines/requirements for generating the Sustainability Criteria (Pre-Stage P7) to be used by both Specification of the Project Proposals (Stage 2) and main Evaluation Selection of Project Proposals (Stage3).	*Not Available*
Pre-Stage P6 Sustainability Constraints	These are used for the determination of setting economic, social, and environment sustainability constraints that are to be utilized (along with sustainability strategy) for generating the Sustainability Criteria (Pre-Stage P7) to be used by both Specification of the Project Proposals (Stage 2) and main Evaluation Selection of Project Proposals (Stage3). In this pre-stage, the Economic, Environment and Social factors are established in linked pre-stages.	*Not Available*
Pre-Stage P7 Generating Sustainability Criteria	Provides detailed guidelines (constraints and requirements) to both Specification of the Project Proposals (Stage 2) and main Evaluation Selection of Project Proposals (Stage3). Here the Sustainability Criteria / Requirements are related to: (1) Environmental Sustainability Requirements: To establish the extent to which the project has considered environmental implications so that negative impacts on environment are either avoided or mitigated. (2) Social Sustainability Requirements: To establish the extent to which the project has considered social implications so that negative impacts on society are either avoided or mitigated. (3) Economic Sustainability Requirements: To establish the extent to which the project has considered economic implications so that negative impacts on the wider economy are either avoided or mitigated?	*Not Available*

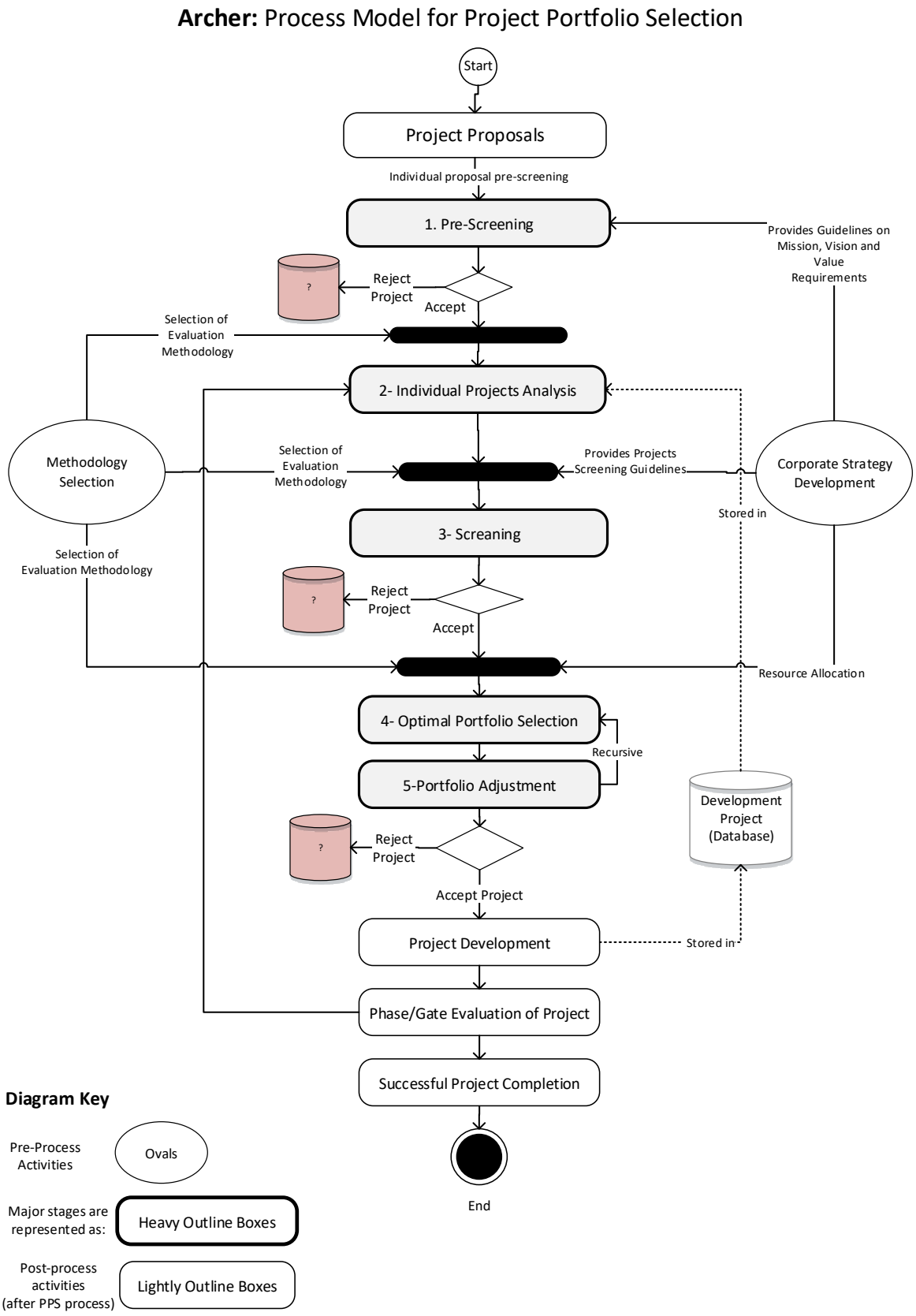


Figure 6: Archer's et. al. PPS Framework's process diagram – Remodelled

In this table a comparison between main process stages is presented:

Stage ID and Stage Name.	***SPPS***	***Archer PPS***
Stage S1 Pre-Screening of Eligible Project Proposals	The process involves making use of organisational corporate strategy to carry out the pre-screening of project proposals.	A pre-process stage provides high-level guidance to the portfolio selection process.
Stage S2 Specification of Project Proposals	The projects accepted in the previous stage of pre-Screening are further Specified (scrutinized) in this stage i.e. named as "Specification of Project Proposals". This stages uses two inputs to carry out the tasks i.e. (1) Operation Constraints that are obtained from Functional Unit Decision Making; (2) Sustainability Criteria Requirements obtained from Organisational Sustainability Strategy and Sustainability (economic, social, and environment) constraints.	S2: Individual Project Analysis In this stage a common set of parameters required for the next stage is calculated separately for each project, based on estimates available from feasibility studies and/or from a database of previously completed projects. For example, project risk, net present worth, return on investment, etc. The output from this stage is a common set of parameter estimates for each project.
Stage S3 Evaluation: Selection of Project Proposals	This is the main evaluation stage where all of the new selected projects and in-progress projects are evaluated based on the evaluation constraints provided by the operational constraints and sustainability criteria pre-stages.	S3: Screening. In this stage project attributes from the previous stage are examined in advance of the regular selection process to eliminate any projects or inter-related families of projects that do not meet pre-set criteria.
Stage S4 Balanced/Optimal Project Portfolio Management	In this stage the aim is to achieve a balanced or optimal portfolio selection where interactions among the various projects are considered, including sustainability, priority, division of resources, planning, project risks, finances etc. Here, the pre-decided common set of parameters help to balance the portfolio selection. The portfolio can be adjusted based on a number of factors or balancing areas.	Optimal Portfolio Selection stage (S4) & Portfolio adjustment (S5): First, a comparative approach such as Q-Sort, pairwise comparison, or AHP, may be used in this step for smaller sets of projects, allowing qualitative as well as quantitative measures to be considered. The final judgmental adjustments are made, which are otherwise difficult to anticipate and include in a model. Moreover, users are able to make changes at this stage.
Stage Pn Selected Projects for Development	The final project(s) selection and the details of final selected projects are recorded in the database along with all of the calculated parameters for future reference.	The selected projects are moved to the development project database along with all of the calculated parameters for future reference.

4.9 Chapter Summary

In this chapter, the SPPS-IT process is introduced, which separates the portfolio selection process into various distinct stages that include pre-processing, data/information flow, main SPPS-IT process stages, post-processing and document stores. In some of the SPPS-IT stages the project portfolio managers apply various evaluation techniques, which have been identified by working with the portfolio managers and programmers at Abu Dhabi Police (ADP) to identify and implement the most suitable techniques. In this chapter, the techniques that are used in various stages for data collection and evaluation are also presented. This proposed SPPS-IT process can help to select a project portfolio that maximises the criteria of interest of their organisation i.e. *in line with their cooperate strategy and sustainability strategy, and which is also suitably balanced on both quantitative and qualitative parameters they choose*.

If the proposed S*PPS-IT* process is to be applied in other originations, their PMO office and/or project portfolio managers are free to choose the evaluation technique they find is/are the most suitable for that stage. This is to allow the decision makes to utilize a desired subset of available evaluation methodologies in easy and logical manner. Moreover, in some of the cases the users may omit a stage if that process was already completed to simplify and expedite the project portfolio selection process.

In the next Chapter 5, implementation of SPPS-IT framework is presented in the case study organisation.

Chapter 5: Empirical Evaluation

5.1 Introduction

This Chapter discuss the empirical evaluation of the proposed SPPS-IT process. The SPPS-IT process is used for selecting a project portfolio that maximises the criteria of interest to the selected case study organisation, which is in line with the cooperate strategy and sustainability strategy, and which was also suitably balanced on both quantitative and qualitative parameters they preferred. As explained in the previous Chapter the overall SPSS-IT process has been divided into various distinct pre-processing, data/information flow, main stages, post-processing and document stores. In this regard, this Chapter provides details on data collection and their methods, all real-life scenarios collected from the case study organisation. Moreover, this chapter presents case study evaluation details and results obtained from these experiments Finally the chapter discusses and concludes overall findings of conducted empirical research.

5.2 Empirical Data Collection – Projects Data

To perform the practical application of this research several projects' data has been collected. This data was collected from case study organisation's Projects Initiation Documents (PID) as well as by holding various in-house focused group sessions with project and portfolio managers. The focused group sessions were mainly conducted to fill-in the missing or unclear data. This has also ensured confirmations on the reliability and completeness of collected projects' data for this research. The following 10 mega IT projects data has been collected and all details of these along with the summaries of collected data are presented in the Appendices:

1. NationalServiceAndFederalReserveSystem-AdpIT786

2. SecuritySystemCompaniesV.3-AdpIT5981

3. SmartLibraryWebsite-AdpIT7861

4. SmsSystemV1.0-AdpLT7823

5. TrafficLicencingSysV4.0-AdpTR7531

6. VisitorReceptionSystem-AdpIT431

7. KioskAutomatesVehicleLicensing-AdpLT2319

8. StatisticsPortsSecuritySystem-AdpLT7801

9. ConditionNotebookV2-AdpLT9765

10. ManagementSystem-AdpIT963

To conduct a thorough practical evaluation of this research the overall evaluation has been divided into two phases named as Phase 1 and Phase 2. In phase 1 following seven projects are considered:

Phase 1

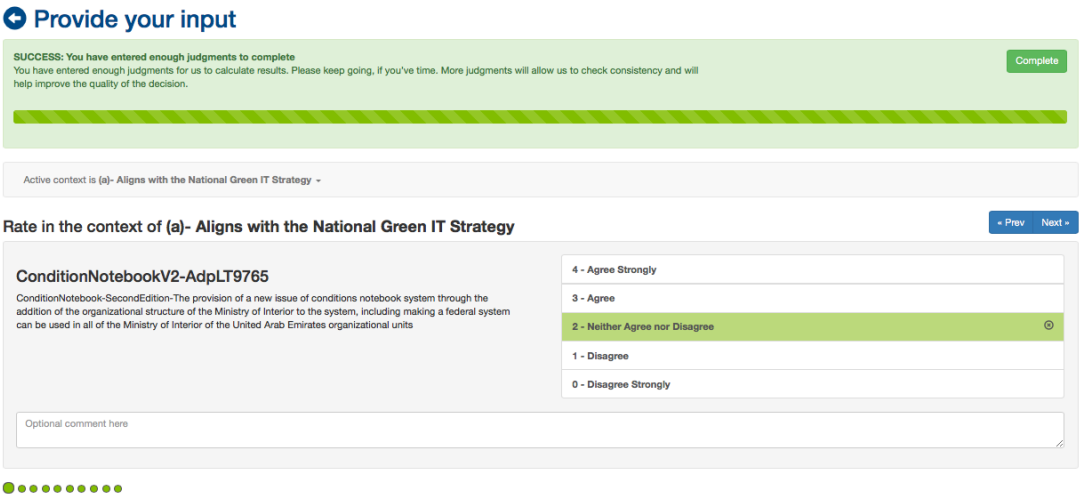
Phase 1 Project 1. *KioskAutomatesVehicleLicensing-AdpLT2319*
Phase 1 Project 2. *NationalServiceAndFederalReserveSystem-AdpIT786*
Phase 1 Project 3. *SecuritySystemCompaniesV.3-AdpIT5981*
Phase 1 Project 4. *SmartLibraryWebsite-AdpIT7861*
Phase 1 Project 5. *SmsSystemV1.0-AdpLT7823*
Phase 1 Project 6. *TrafficLicencingSysV4.0-AdpTR7531*
Phase 1 Project 7. *VisitorReceptionSystem-AdpIT431*

In the second Phase (2) the top three selected projects were taken out of the portfolio of projects, which was decided after the implementation of Phase 1, which is detailed later in this chapter. These three projects are replaced with and another set of three projects. Overall, in phase 2 following seven projects are considered:

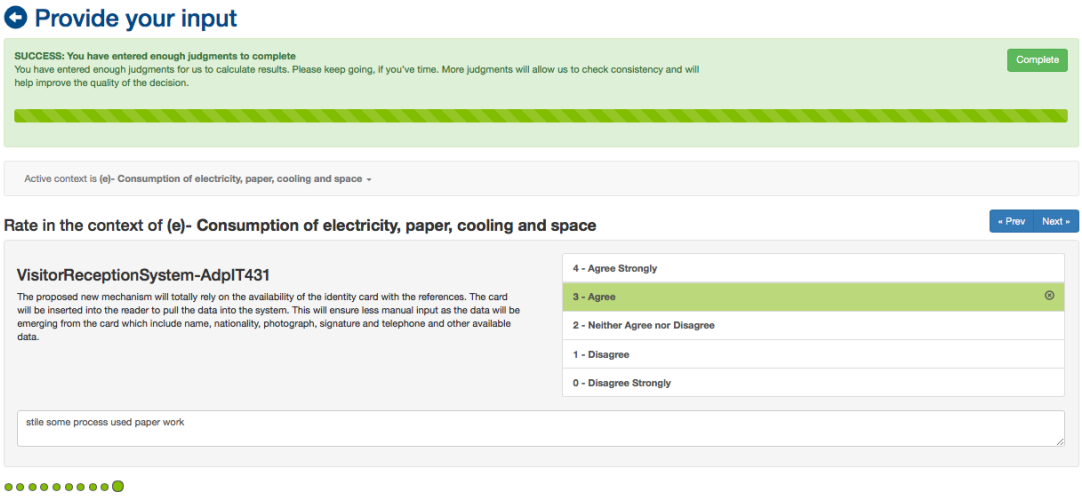
Phase 2

Phase 2 Project 1. *ConditionNotebookV2-AdpLT9765*
Phase 2 Project 2. *ManagementSystem-AdpIT963*
Phase 2 Project 3. *SmartLibraryWebsite-AdpIT7861*
Phase 2 Project 4. *StatisticsPortsSecuritySystem-AdpLT7801*
Phase 2 Project 5. *TrafficLicencingSysV4.0-AdpTR7531*
Phase 2 Project 6. *VisitorReceptionSystem-AdpIT431*
Phase 2 Project 7. *KioskAutomatesVehicleLicensing-AdpLT2319*

The following are the 2 x example screen shots showing how projects' data collection and entry into the system was carried out. Overall, there were 1000's of data entry screen like this and it is not practical to show all screen shots. Therefore, summarised details of collected data and related criteria distributions are presented in the Appendices.



Projects' data entry example screen shot 1



Projects' data entry example screen shot 2

5.3 Empirical Evaluation and Findings

Once all the projects data in a portfolio have been evaluated; as discussed in the above sections, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects using different portfolio-balancing policies. These portfolio-balancing policies helped portfolio managers in achieving a portfolio that met both the strategic and sustainability objectives of the organisation optimally. Therefore, while applying a portfolio-balancing policy all relevant evaluation information of the projects and evaluation factors scoring /ranking were already made available to allow decision makers to evaluate the portfolio and make informed decisions.

In this research, after closely working with the case study organisation's portfolio managers and policy makers, the evaluation criteria's priorities are defined based on the different levels of portfolio balancing needs. This was done in 13 different scenarios of evaluation criteria's priorities specifications. However, the number of scenarios could be increased or decreased depending on individual organisational needs. Overall, there could be several possible scenarios with different levels of criteria priorities but not all of them are applicable to an organisation. The choice of scenarios presented in this dissertation are sufficiently covering all aspects of this research, which were finalised after working with the case study organisation's portfolio managers and policy makers. The details of pairwise comparisons in these scenarios have been already specified in previous sections of this chapter. The details on findings on portfolio policies and the benefits obtained by including priorities are discussed in this section.

5.3.1 Policy 1

The application of Policy 1 is essential to achieve a balanced portfolio of projects. This policy allows us to define the portfolio evaluation criteria priorities based on the portfolio-balancing requirements identified by the case study organisation.

The first part or the pre-requisite of Policy 1 is, "define the portfolio evaluation criteria priorities based on the portfolio balancing requirement in ten (10) different scenarios". This enabled the feeding of all projects (also called alternatives) portfolio data into the system for AHP evaluation. The second part of Policy 1 stated: "for all the scenarios, obtain and process all projects (alternatives) portfolio data as per the

defined portfolio evaluation criteria", which is discussed in the later sections of this Chapter. Because of the application of Part 1 of the Policy 1, projects portfolio evaluation criteria in 10 different levels of priorities is achieved, which are presented as follows:

5.3.1.1 Scenario 1

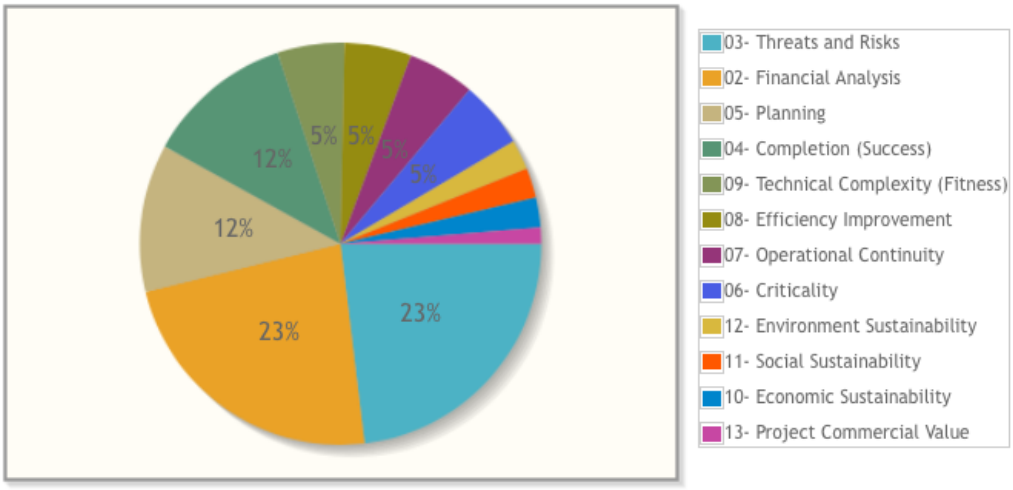
This section describes the Scenario 1, where by working with the case study organisation five different levels of priorities were specified. Here, the "Extremely Most Important" is the highest required level, followed by "Most Important", "Medium Important", "Less Important" and "Extremely Less Important" is the lowest level of priority. In scenario 1, the Financial Analysis, and Protection from Threats and Risks were considered as Extremely Most Important. The Completion (Success) and Planning were considered as Most Important, followed by Criticality, Operational Continuity, Efficiency Improvement, Technical Complexity (Fitness) as Medium Important. This is to be noted here that in this very first scenario deliberated by the case study organisation, sustainability wasn't considered as the Extremely Most Important priority. This was primarily done to first see the outcome of projects selection under normal circumstances. In this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Less Important. Finally, the Project Commercial Value was given the least priority in this scenario, which is Extremely Less Important. In small and medium-sized enterprises (SMEs), this could be the case that Project Commercial Value is one of the most important priorities. The case study organisation was a very large public/government organisation; and for them, Project Commercial Value is never that important. However, such situation is dealt in the scenarios described later. The following Table shows the distribution of scenario 1 criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 1				
Financial Analysis	Completion (Success)	Criticality	Economic Sustainability	Project Commercial Value
Protection from Threats and Risks	Planning	Operational Continuity	Social Sustainability	
		Efficiency Improvement	Environment Sustainability	
		Technical Complexity (Fitness)		

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 1	Scores
01 - Financial Analysis	23.1
02 - Threats and Risks	23.1
03 - Completion (Success)	11.9

04 - Planning	11.9
05 - Criticality	5.4
06 - Operational Continuity	5.4
07 - Efficiency Improvement	5.4
08 - Technical Complexity (Fitness)	5.4
09 - Economic Sustainability	2.4
10 - Social Sustainability	2.4
11 - Environment Sustainability	2.4
12 - Project Commercial Value	1.3



5.3.1.2 Scenario 2

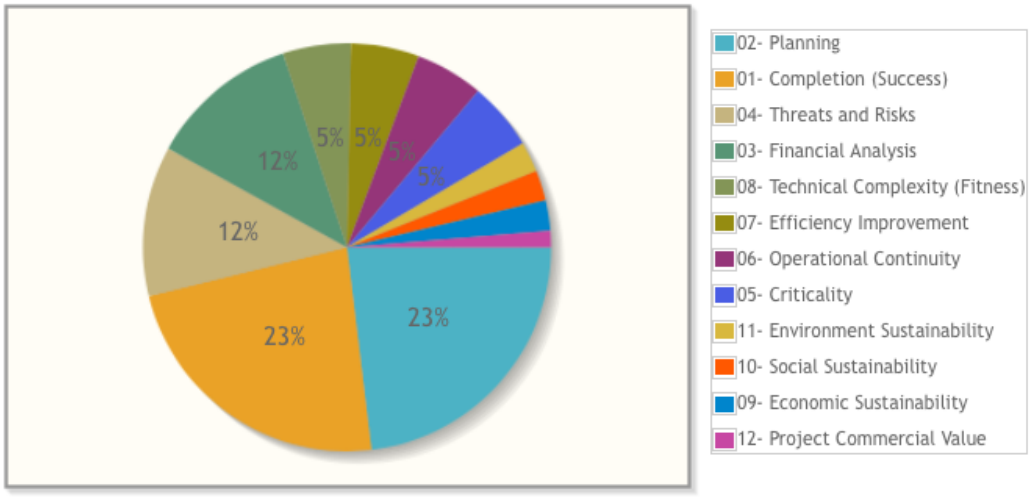
In scenario 2, the Project Completion (also called Project Success) and Project Planning were considered as Extremely Most Important. This is because sometime in a portfolio, portfolio managers look for the project success and completion as most important. This is especially done when all the projects are equally important and organisational funding is limited. However, there could be other reasons for doing this e.g. such as timely and successful delivery of government services etc. In this scenario, Financial Analysis and Protection from Threats and Risks are considered as Most Important, followed by Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) as Medium Important. This is to be noted here that in this second scenario again sustainability wasn't considered as the Extremely Most Important, Most Important or Medium Important priority. This was again primarily done to see the outcome of projects selection under normal circumstances where project success and completing are extremely important in comparison with sustainability. Consequently, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Less Important. Finally, the Project Commercial Value was again given the least priority in this scenario, which is Extremely Less Important. The following Table shows the distribution of scenario 2 criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 2				
Completion (Success)	Financial Analysis	Criticality	Economic Sustainability	Project Commercial

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
				Value
Planning	Protection from Threats and Risks	Operational Continuity	Social Sustainability	
		Efficiency Improvement	Environment Sustainability	
		Technical Complexity (Fitness)		

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 2	Scores
01 - Completion (Success)	23.1
02 - Planning	23.1
03 - Financial Analysis	11.9
04 - Threats and Risks	11.9
05 - Criticality	5.4
06 - Operational Continuity	5.4
07 - Efficiency Improvement	5.4
08 - Technical Complexity (Fitness)	5.4
09 - Economic Sustainability	2.4
10 - Social Sustainability	2.4
11 - Environment Sustainability	2.4
12 - Project Commercial Value	1.3



5.3.1.3 Scenario 3

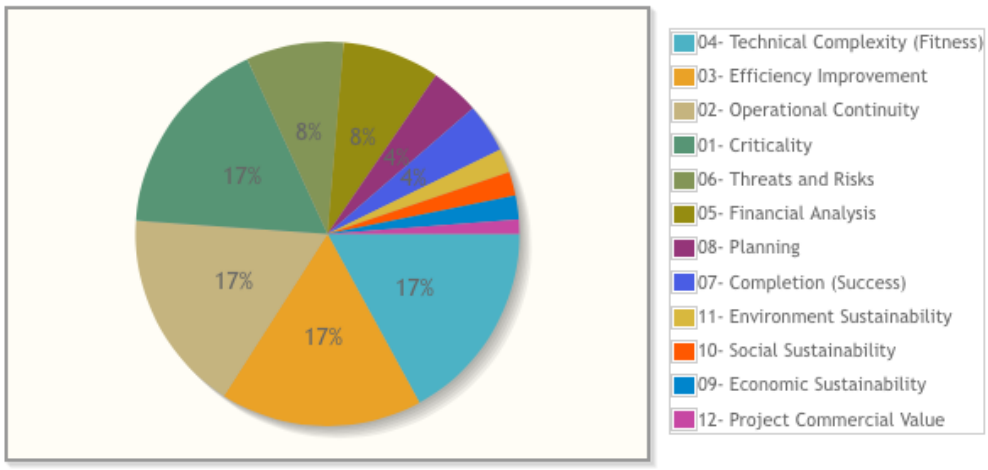
In scenario 3, the main emphasis has been given to those factors that are related to the Operational Continuity of an organisation. While selecting Operational Continuity as the main factor, the portfolio managers also selected project Criticality, Efficiency Improvement and Technical Complexity (Fitness) as equally important. According to the portfolio managers, while considering Operational Continuity they don't usually want to end up selecting those project that are extremely complex and the preference should always be given to project which are comparatively less complex. Moreover,

Financial Analysis and Protection from Threats and Risks are considered as second Most Important factors, followed by Completion and Planning as Medium Important. In this scenario again sustainability wasn't considered as the Extremely Most Important, Most Important or Medium Important priority. This was again primarily done in order to see the outcome of projects selection under normal circumstances where project Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) are extremely important in comparison with sustainability. Consequently, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Less Important. Finally, the Project Commercial Value was once again given the least priority in this scenario, which is Extremely Less Important. The following Table shows the aforementioned distribution of scenario 3 criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 3				
Criticality	Financial Analysis	Completion (Success)	Economic Sustainability	Project Commercial Value
Operational Continuity	Protection from Threats and Risks	Planning	Social Sustainability	
Efficiency Improvement			Environment Sustainability	
Technical Complexity (Fitness)				

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 3	Scores
01 - Criticality	17
02 - Operational Continuity	17
03 - Efficiency Improvement	17
04 - Technical Complexity (Fitness)	17
05 - Financial Analysis	8.2
06 - Threats and Risks	8.2
07 - Completion (Success)	4.1
08 - Planning	4.1
09 - Economic Sustainability	2
10 - Social Sustainability	2
11 - Environment Sustainability	2
12 - Project Commercial Value	1.2



5.3.1.4 Scenario 4

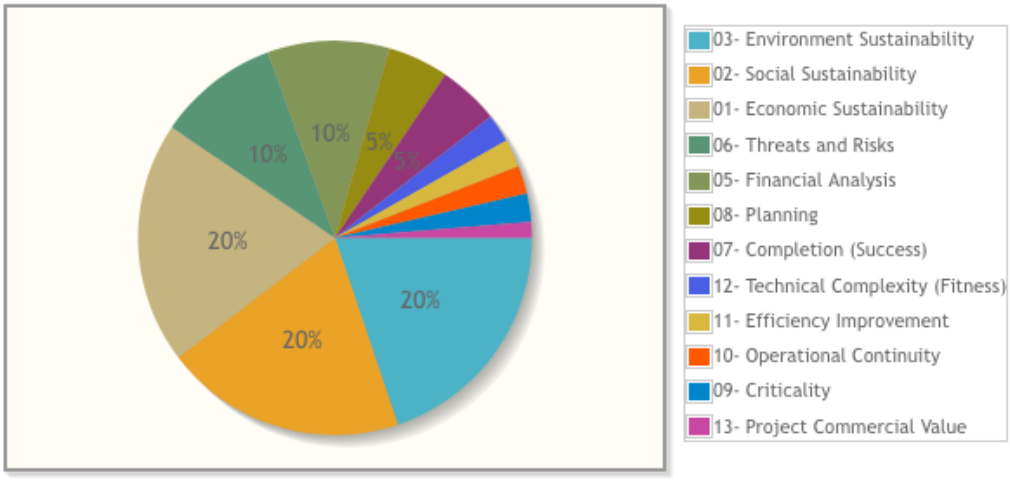
After defining the 3 x above scenarios without considering Sustainability as a main critical factor, in scenario 4 Sustainability was taken as the Most Important Factor. Hence, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Extremely Most Important. In order to observe the impact of this scenario with previous scenario, Financial Analysis and Protection from Threats and Risks are considered as second Most Important factors, followed by Completion and Planning as Medium Important. Similarly, the Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) are defined as Less Important. Finally, the Project Commercial Value was again given the least priority in this scenario, which is Extremely Less Important. This was done to ensure that in this scenario Project Commercial Value has minimum impact on project selection. The following Table shows the distribution of criteria of scenario 4 into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 4				
Economic Sustainability	Financial Analysis	Completion (Success)	Criticality	Project Commercial Value
Social Sustainability	Protection from Threats and Risks	Planning	Operational Continuity	
Environment Sustainability			Efficiency Improvement	
			Technical Complexity (Fitness)	

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 4	Scores
01 - Economic Sustainability	19.8
02 - Social Sustainability	19.8
03 - Environment Sustainability	19.8
04 - Financial Analysis	10

05 - Threats and Risks	10
06 - Completion (Success)	5
07 - Planning	5
08 - Criticality	2.3
09 - Operational Continuity	2.3
10 - Efficiency Improvement	2.3
11 - Technical Complexity (Fitness)	2.3
12 - Project Commercial Value	1.3



5.3.1.5 Scenario 5

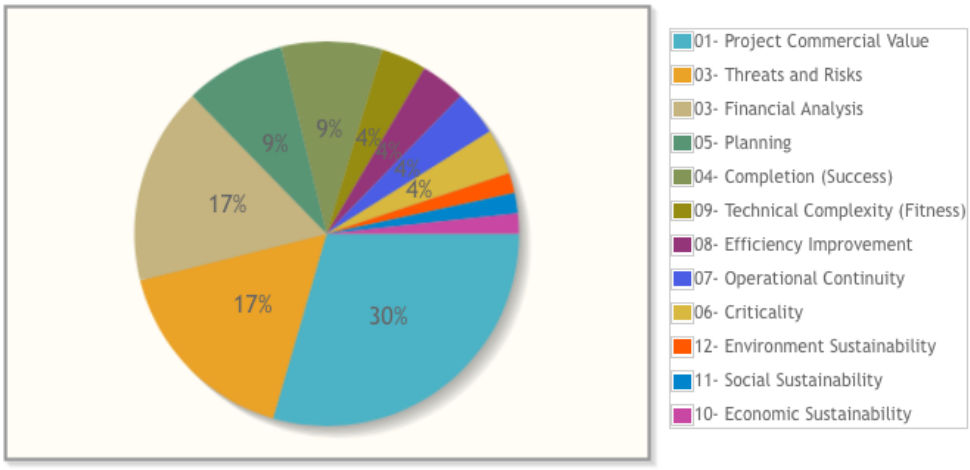
Scenario 5 is contrasting to the scenario 4 where Project Commercial Value has been given the Extremely Most Important priority. Sometimes organisations are obliged to give Project Commercial Value as the most important priority in a portfolio. In this scenario, sustainability is still considered as a factor; however, it has minimal influence on the selection as all Economic Sustainability, Social Sustainability and Environment Sustainability are defined as Extremely Less Important. The rest of the criteria have been kept like the previous scenario so that the impact of giving highest priority to Project Commercial Value in comparison with sustainability could be observed and/or considered by the portfolio manager. Consequently, Financial Analysis and Protection from Threats and Risks are considered as second Most Important factors, followed by Completion and Planning as Medium Important. Similarly, the Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) are defined as Less Important. The following Table shows the distribution of criteria for scenario 5 into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 5				
Project Commercial Value	Financial Analysis	Completion (Success)	Criticality	Economic Sustainability
	Protection from Threats and Risks	Planning	Operational Continuity	Social Sustainability
			Efficiency Improvement	Environment Sustainability

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
			Technical Complexity (Fitness)	

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 5	Scores
01 - Project Commercial Value	29.5
03 - Financial Analysis	16.6
03 - Threats and Risks	16.6
04 - Completion (Success)	8.5
05 - Planning	8.5
06 - Criticality	3.8
07 - Operational Continuity	3.8
08 - Efficiency Improvement	3.8
09 - Technical Complexity (Fitness)	3.8
10 - Economic Sustainability	1.7
11 - Social Sustainability	1.7
12 - Environment Sustainability	1.7



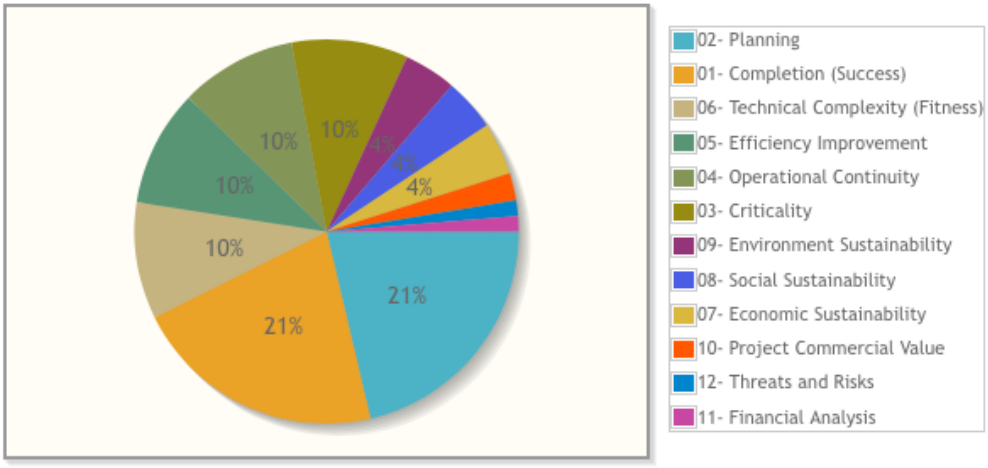
5.3.1.6 Scenario 6

This scenario provided a completely different view of priorities. In contradiction with above scenarios, here the Financial Analysis and Protection from Threats and Risks were considered as Extremely Less Important factors. In this scenario, Completion (Success) and Planning were considered as Extremely Most Important. This has been followed by the other critical factors that include Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness), which have been defined as Most Important. Another important priority decision in this scenario was to keep sustainability as a natural priority; and therefore, Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Medium Important. Finally, the remaining Project Commercial Value was given Less Important priority. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 6				
Completion (Success)	Criticality	Economic Sustainability	Project Commercial Value	Financial Analysis
Planning	Operational Continuity	Social Sustainability		Protection from Threats and Risks
	Efficiency Improvement	Environment Sustainability		
	Technical Complexity (Fitness)			

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 6	Scores
01 - Completion (Success)	21.3
02 - Planning	21.3
03 - Criticality	9.8
04 - Operational Continuity	9.8
05 - Efficiency Improvement	9.8
06 - Technical Complexity (Fitness)	9.8
07 - Economic Sustainability	4.4
08 - Social Sustainability	4.4
09 - Environment Sustainability	4.4
10 - Project Commercial Value	2.3
11 - Financial Analysis	1.3
12 - Threats and Risks	1.3



5.3.1.7 Scenario 7

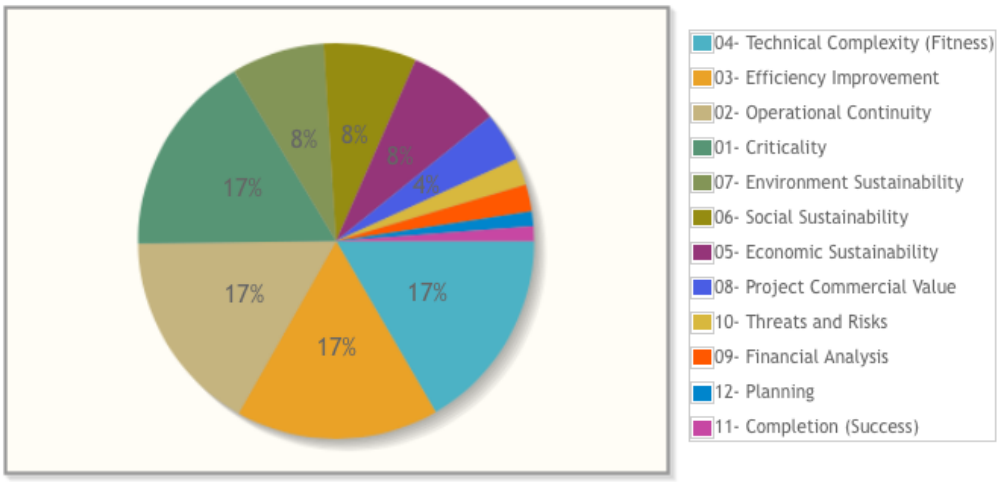
This scenario presents another interesting distribution of priorities. In scenario 7, the main emphasis has been again given to those factors that are related to the Operational Continuity of an organisation. However, in the scenario sustainability has been given the second most important priority. Moreover, while selecting Operational

Continuity as the main factor, the portfolio managers also selected project Criticality, Efficiency Improvement and Technical Complexity (Fitness) as equally important. Consequently, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Most Important. Another important, change in this scenario was giving natural place to Project Commercial Value to minimise it effect on the portfolio selection; and therefore, it has been defined as Medium Important. In order to deal with rare situations where Financial Analysis and Protection from Threats and Risks are not as important as operational continuity, in this scenario all such factors have been defined as Less Important. Finally, in complete contrast with previous scenario this scenario considers Completion and Planning as the Extremely Least Important Factors. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 7				
Criticality	Economic Sustainability	Project Commercial Value	Financial Analysis	Completion (Success)
Operational Continuity	Social Sustainability		Protection from Threats and Risks	Planning
Efficiency Improvement	Environment Sustainability			
Technical Complexity (Fitness)				

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 7	Scores
01 - Criticality	16.6
02 - Operational Continuity	16.6
03 - Efficiency Improvement	16.6
04 - Technical Complexity (Fitness)	16.6
05 - Economic Sustainability	7.6
06 - Social Sustainability	7.6
07 - Environment Sustainability	7.6
08 - Project Commercial Value	4
09 - Financial Analysis	2.2
10 - Threats and Risks	2.2
11 - Completion (Success)	1.2
12 - Planning	1.2



5.3.1.8 Scenario 8

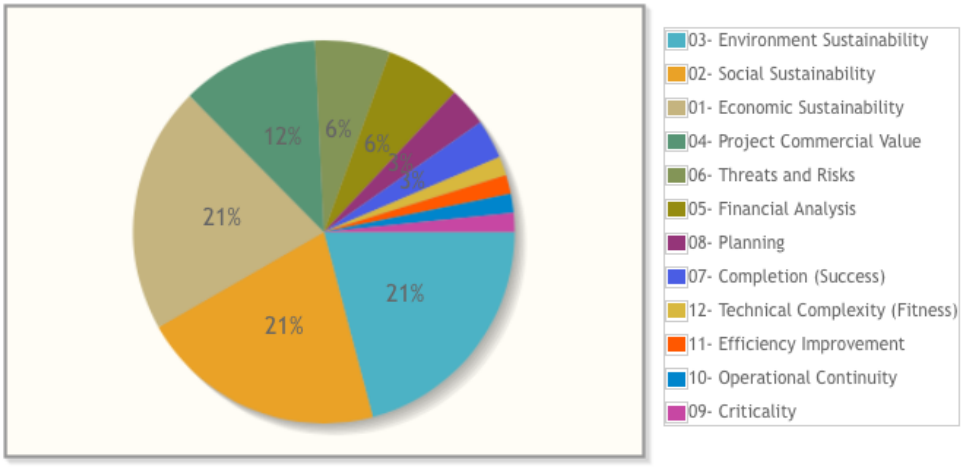
In this scenario sustainability is once again considered as the main priority to observe its impact as compared to the previous scenarios. Hence, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Extremely Most Important. Moreover, in contrast with scenario 4 where Project Commercial Value was given the least priority i.e. Extremely Less Important, this scenario 8 considers Project Commercial Value at the second highest priority i.e. Most Important. Now to level the other factors with previous scenario and also to deal with rare situations where Financial Analysis and Protection from Threats and Risks are not as important as sustainability, in this scenario all these factors have been defined Less Important. Similarly, this scenario considers Completion and Planning as the Extremely Least Important factors. In order to naturalise the effect of financial constraints as well as project risk, in this scenario Financial Analysis and Protection from Threats and Risks are given the priority as Medium Important. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 8				
Economic Sustainability	Project Commercial Value	Financial Analysis	Completion (Success)	Criticality
Social Sustainability		Protection from Threats and Risks	Planning	Operational Continuity
Environment Sustainability				Efficiency Improvement
				Technical Complexity (Fitness)

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 8	Scores
01 - Economic Sustainability	20.9
02 - Social Sustainability	20.9
03 - Environment Sustainability	20.9

04 - Project Commercial Value	11.7
05 - Financial Analysis	6.4
06 - Threats and Risks	6.4
07 - Completion (Success)	3.3
08 - Planning	3.3
09 - Criticality	1.6
10 - Operational Continuity	1.6
11 - Efficiency Improvement	1.6
12 - Technical Complexity (Fitness)	1.6



5.3.1.9 Scenario 9

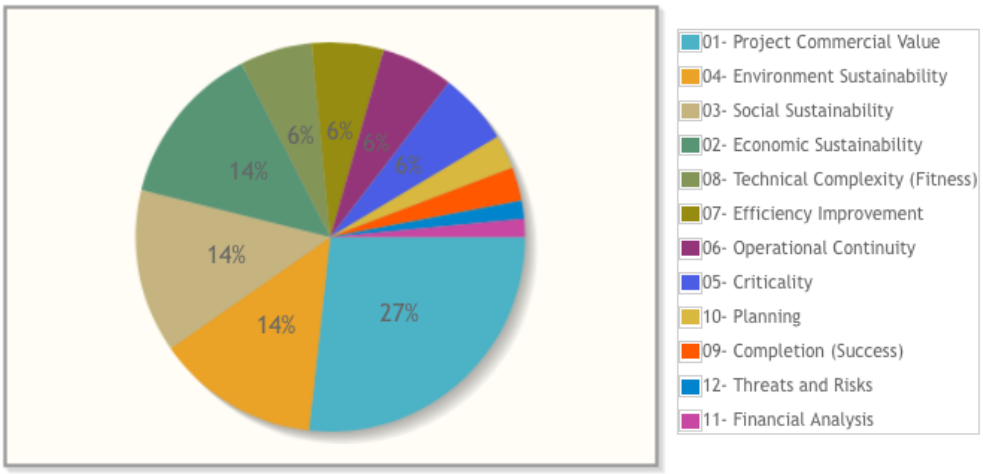
In scenario 9, Project Commercial Value has been considered by bundling it with sustainability. It has been considered that sometimes organisations are obliged to give Project Commercial Value as the main priority in a portfolio while also giving a high consideration to sustainability. Therefore, in this scenario Project Commercial Value is considered as the Extremely Most Important priority and all Economic Sustainability, Social Sustainability and Environment Sustainability are defined as Most Important. Moreover, the factors related to organisation operations and project complexly has been neutralised by giving Medium Important priority to Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness). In most of the above scenarios Finances and Risks were given high priority. However, while combining sustainability factors with Project Commercial Value as high priorities, in this scenario all other factors have been consequently given least priorities. So, both Completion (Success) and Planning are defined as Less Important, and the rest of the factors i.e. Financial Analysis and Protection from Threats and Risks has been defined as Extremely Less Important. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Scenario 9				
Project Commercial Value	Economic Sustainability	Criticality	Completion (Success)	Financial Analysis
	Social Sustainability	Operational Continuity	Planning	Protection from Threats and

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
				Risks
	Environment Sustainability	Efficiency Improvement		
		Technical Complexity (Fitness)		

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions.

Scenario 9	Scores
01 - Project Commercial Value	26.8
02 - Economic Sustainability	13.6
03 - Social Sustainability	13.6
04 - Environment Sustainability	13.6
05 - Criticality	6
06 - Operational Continuity	6
07 - Efficiency Improvement	6
08 - Technical Complexity (Fitness)	6
09 - Completion (Success)	2.8
10 - Planning	2.8
11 - Financial Analysis	1.5
12 - Threats and Risks	1.5



5.3.1.10 Scenario 10

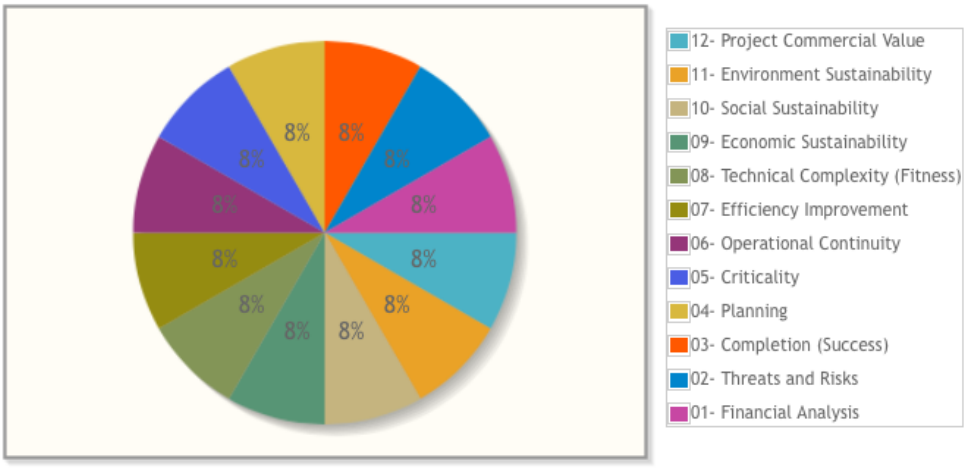
After defining all the above scenarios, it was decided to come up with a scenario where all the factors are given equal importance. This was necessary to not only see the outcome of such portfolio, but to also compare the outcomes with all the above scenarios. Therefore, in scenario 10 all Financial Analysis, Protection from Threats and Risks, Completion (Success), Planning, Criticality, Operational Continuity, Efficiency Improvement Technical Complexity (Fitness), Economic Sustainability, Social Sustainability, Environment Sustainability and Project Commercial Value are given Equally Important priority. Moreover, organisations may edit this scenario and remove one of more factors which they feel are not required for their portfolio. In this

way, they will be able to customize the portfolio according to their preferences. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Equally Important	Less Important	Extremely Less Important
Scenario 10				
		Financial Analysis		
		Protection from Threats and Risks;		
		Completion (Success)		
		Planning		
		Criticality		
		Operational Continuity		
		Efficiency Improvement		
		Technical Complexity (Fitness)		
		Economic Sustainability		
		Social Sustainability		
		Environment Sustainability		
		Project Commercial Value		

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions. As it can be observed that all criteria have scored equally as in this scenario all criteria was considered as equally important.

Scenario 10	Scores
01 - Financial Analysis	8.3
02 - Threats and Risks	8.3
03 - Completion (Success)	8.3
04 - Planning	8.3
05 - Criticality	8.3
06 - Operational Continuity	8.3
07 - Efficiency Improvement	8.3
08 - Technical Complexity (Fitness)	8.3
09 - Economic Sustainability	8.3
10 - Social Sustainability	8.3
11 - Environment Sustainability	8.3
12 - Project Commercial Value	8.3



The first part or the pre-requisite of Policy 1 stated, "define the portfolio evaluation criteria priorities based on the portfolio balancing requirement in (10) different scenarios", which enabled the feeding of all the above projects (alternatives) portfolio data into the system for AHP evaluation. The second part of Policy 1 stated: "for all the scenarios, obtain and process all projects (alternatives) portfolio data as per the defined portfolio evaluation criteria". Because of the application of Policy 1 Part 2, the resultant individual projects' scores based on the AHP were achieved. In this section, these results are discussed. Note that in this section only the findings on individual scenarios with related findings are presented; whereas; in later sections, more comparative discussion and findings across all scenarios are provided.

5.3.1.11 Outcomes of Scenario 1 Projects Portfolio Data

The outcomes of Scenario 1 show that the SecuritySystemCompaniesV.3-AdpIT5981 project stands out clearly in the entire portfolio scoring 0.942. When the scores are "rounded" for all projects, it can be noticed that top four (04) project have scored close of 0.9 in this portfolio of projects. These four projects include SecuritySystemCompaniesV.3-AdpIT5981, SmsSystemV1.0-AdpLT7823 with a score of 0.92, SmartLibraryWebsite-AdpIT7861 with a score 0.899 and VisitorReceptionSystem-AdpIT431 with a score 0.894. On further analysis by going back to original priority criteria, it was observed that in this scenario Financial Analysis and Protection from Threats and Risks were considered as Extremely Most Important. These four projects fully strategically aligned with organisational objectives. On the other side, these four top selections are public non-profit projects with no commercial value. However, they were still selected as best because in this scenario the Project Commercial Value was given the least priority, which was Extremely Less Important.

Moreover, in this scenario Completion (Success) and Planning were considered as Most Important, followed by Criticality, Operational Continuity, Efficiency Improvement, Technical Complexity (Fitness) as Medium Important. Form this scenario the standing of sustainability cannot be established, which is because in this very first scenario deliberated by the case study organisation, sustainability wasn't considered as an Important priority. This was primarily done to see the outcome of projects selection under normal circumstances. Thus, Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Less Important.

If the portfolio managers need to select top five projects from this portfolio, then they can straightforwardly select NationalServiceAndFederalReserveSystem-AdpIT786 project that scored 0.871. This is because there is less difference in the scores of NationalServiceAndFederalReserveSystem-AdpIT786 and Visitor-ReceptionSystem-AdpIT431 projects.

S. No	Scenario 1	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.942
2	SmsSystemV1.0-AdpLT7823	0.92
3	SmartLibraryWebsite-AdpIT7861	0.899
4	VisitorReceptionSystem-AdpIT431	0.894
5	NationalServiceAndFederalReserveSystem-AdpIT786	0.871
6	KioskAutomatesVehicleLicensing-AdpLT2319	0.826
7	TrafficLicencingSysV4.0-AdpTR7531	0.783

5.3.1.12 Outcomes of Scenario 2 Projects Portfolio Data

In this scenario, various interesting findings have been observed. The first important finding is that in this scenario the resultant projects ranking order is the same as in the scenario 1. However, the total scores values are obviously different. Looking at the actual factor priorities, the Project Completion (also called Project Success) and Project Planning were considered as Extremely Most Important. Moreover, Financial Analysis and Protection from Threats and Risks were considered as Most Important, followed by Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) as Medium Important. Rest of the factors remained the same as in scenario one. The outcome/finding of this scenario is that: they're not many changes in terms of projects' ranking when the priority order of Project Completion (also called Project Success) and Project Planning is swapped with Financial Analysis and Protection from Threats and Risks.

Although, the resultant ranking order of the projects came the same, this scenario gave better results as compared with scenario one. In scenario one, the SecuritySystemCompaniesV.3-AdpIT5981 project did stood out clearly in the entire portfolio scoring 0.942. But on rounding the scores of all projects, it was noticed that all four top projects had scored close to 0.9. These four projects include SecuritySystemCompaniesV.3-AdpIT5981 scoring 0.953, SmsSystemV1.0-AdpLT7823 with a score of 0.92, SmartLibraryWebsite-AdpIT7861 with a score 0.899 and VisitorReceptionSystem-AdpIT431 scored 0.894. However, in scenario 2, when scores were rounded for all projects it was noticed that all four top projects; and especially the top three projects, didn't scored very closely. In this scenario, SecuritySystemCompaniesV.3-AdpIT5981 scored 0.953, SmsSystemV1.0-AdpLT7823 scored 0.934, SmartLibraryWebsite-AdpIT7861 scored 0.896 and VisitorReceptionSystem-AdpIT431 scored 0.888. The score of 5th project was far away then the top four projects, which was also not the case in scenario 1. Thus, looking at the comparatively distinct scores in scenario 2, it has provided slightly more flexibility to the portfolio managers to select any number of projects.

S. No	Scenario 2	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.953

2	SmsSystemV1.0-AdpLT7823	0.934
3	SmartLibraryWebsite-AdpIT7861	0.896
4	VisitorReceptionSystem-AdpIT431	0.888
5	NationalServiceAndFederalReserveSystem-AdpIT786	0.854
6	KioskAutomatesVehicleLicensing-AdpLT2319	0.827
7	TrafficLicencingSysV4.0-AdpTR7531	0.769

5.3.1.13 Outcomes of Scenario 3 Projects Portfolio Data

The outcomes of scenario 3 gave further interesting findings as compared to the previous 2 scenarios. In contradiction to previous two scenarios, in this scenario the top five projects are SecuritySystemCompaniesV.3-AdpIT5981 scoring 0.884 TrafficLicencingSysV4.0-AdpTR75310 scoring 0.876, SmsSystemV1.0-AdpLT7823 scoring 0.856, ManagementSystem-AdpIT963 scoring 0.839 and NationalServiceAndFederalReserveSystem-AdpIT786 0.835. In this scenario, the main emphasis has been given to those factors that are related to the Operational Continuity of an organisation. While selecting Operational Continuity as the main factor, the portfolio managers also selected project Criticality, Efficiency Improvement and Technical Complexity (Fitness) as equally important. Moreover, Financial Analysis and Protection from Threats and Risks has been considered as second Most Important factors, followed by Completion and Planning as Medium Important. In this scenario, again sustainability wasn't considered as the Extremely Most Important, Most Important or Medium Important priority. As discussed above, this was again primarily done in order to see the outcome of projects selection under normal circumstances where project Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) are extremely important in comparison with sustainability. Consequently, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Less Important. Another interesting finding of this scenario is that only the top three project stood out clearly that are SecuritySystemCompaniesV.3-AdpIT5981 scoring 0.884 TrafficLicencingSysV4.0-AdpTR75310 scoring .876, SmsSystemV1.0-AdpLT7823 scoring 0.856. However, after the first three the next three projects scored nearly close to 0.83 i.e. NationalServiceAndFederalReserve-System-AdpIT786 scored 0.835 and VisitorReceptionSystem-AdpIT431 scored 0.834. Therefore, with such results the portfolio managers could either go with the top three or top six projects.

S. No	Scenario 3	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.884
2	TrafficLicencingSysV4.0-AdpTR7531	0.876
3	SmsSystemV1.0-AdpLT7823	0.856
4	NationalServiceAndFederalReserveSystem-AdpIT786	0.835
5	VisitorReceptionSystem-AdpIT431	0.834
6	KioskAutomatesVehicleLicensing-AdpLT2319	0.823
7	SmartLibraryWebsite-AdpIT7861	0.797

5.3.1.14 Outcomes of Scenario 4 Projects Portfolio Data

In this scenario the main finding is related to the sustainability factors. As discussed above, after defining three above scenarios without considering

Sustainability as a main critical factor, in scenario 4 Sustainability was taken as the Most Important Factor. Hence, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Extremely Most Important. The finding of this scenario is that it produced very different results as compared to previous scenario where sustainability wasn't considered as one of the main factors. The five projects which scored the highest include SmsSystemV1.0-AdpLT7823 scoring 0.963, SecuritySystemCompaniesV.3-AdpIT5981 scoring 0.953, NationalServiceAndFederalReserveSystem-AdpIT786 scoring 0.943, Kiosk-AutomatesVehicleLicensing-AdpLT2319 scoring 0.923 and TrafficLicencingSysV4.0-AdpTR7531 scoring 0.906. Interestingly, the rest of the projects in the portfolio scored extremely low as compared to the top five projects; for example, VisitorReceptionSystem-AdpIT431 that is on number 6th scored 0.725, which is far less than the 5th scoring project. Consequently, the outcomes on this portfolio are quite straightforward for decision-making. Another further observation is that in this scenario 4, when sustainability has been considered as main factor the project KioskAutomatesVehicleLicensing-AdpLT2319 came on 4th selectable position, whereas in previous scenarios it was on the 7th number. Thus, it has been practically found out that selecting Sustainability as the Extremely Most Important factor does changes the portfolio selection outcomes to a large extant.

S. No	Scenario 4	Scores
1	SmsSystemV1.0-AdpLT7823	0.963
2	SecuritySystemCompaniesV.3-AdpIT5981	0.953
3	NationalServiceAndFederalReserveSystem-AdpIT786	0.943
4	KioskAutomatesVehicleLicensing-AdpLT2319	0.923
5	TrafficLicencingSysV4.0-AdpTR7531	0.906
6	VisitorReceptionSystem-AdpIT431	0.725
7	SmartLibraryWebsite-AdpIT7861	0.699

5.3.1.15 Outcomes of Scenario 5 Projects Portfolio Data

This main important consideration in this scenario was Project Commercial Value, which was given the Extremely Most Important priority. This was contrasting to previous scenarios where Project Commercial Value was on the Extremely Less Important priority. This scenario was built to support the argument that sometimes organisations are obliged to give Project Commercial Value as the most important priority in a portfolio. In this scenario, sustainability was still considered as a factor; however, it had minimal influence on the selection as all Economic Sustainability, Social Sustainability and Environment Sustainability were defined as Extremely Less Important. The rest of the criteria have been kept similar to the previous scenario so that the impact of giving highest priority to Project Commercial Value in comparison with sustainability could be observed and/or considered by the portfolio manager.

The notable finding in this scenario is the score and ranking of SmsSystemV1.0-AdpLT7823 project that scored 0.849 and came on number five. In all previous scenarios, SmsSystemV1.0-AdpLT7823 remained within the top three projects. The top five projects in this scenario are SecuritySystemCompaniesV.3-AdpIT5981 scored 0.959, SmartLibraryWebsite-AdpIT7861 scored 0.913, VisitorReceptionSystem-AdpIT431 scored 0.887, NationalServiceAndFederalReserveSystem-AdpIT786 scored 0.857 and

SmsSystemV1.0-AdpLT7823 scored 0.849. Another notable finding in this scenario is the score and ranking of VisitorReceptionSystem-AdpIT431 project that scored 0.887 and came on quite selectable position of number three. In all the previous scenarios', portfolios VisitorReceptionSystem-AdpIT431 remained at the 6th position. Thus, it can be concluded that giving Project Commercial Value as the most important priority in a portfolio does impacts the portfolio outcomes, which is especially the case when all Economic Sustainability, Social Sustainability and Environment Sustainability are defined as Extremely Less Important.

S. No	Scenario 5	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.959
2	SmartLibraryWebsite-AdpIT7861	0.913
3	VisitorReceptionSystem-AdpIT431	0.887
4	NationalServiceAndFederalReserveSystem-AdpIT786	0.857
5	SmsSystemV1.0-AdpLT7823	0.849
6	TrafficLicencingSysV4.0-AdpTR7531	0.845
7	KioskAutomatesVehicleLicensing-AdpLT2319	0.804

5.3.1.16 Outcomes of Scenario 6 Projects Portfolio Data

This scenario considered Completion (Success) and Planning as Extremely Most Important factors. Moreover, in contradiction with above scenarios, here the Financial Analysis, and Protection from Threats and Risks were considered as Extremely Less Important factors. The finding of this scenario is that, the resultant portfolio only gave two high scoring projects, that are SecuritySystemCompaniesV.3-AdpIT5981 scored 0.932 and SmsSystemV1.0-AdpLT7823 scored 0.913. The projects that came on ranking 3, 4 and 5 almost scored the same i.e. NationalServiceAndFederalReserveSystem-AdpIT786 scored 0.843, VisitorReceptionSystem-AdpIT431 scored 0.84 KioskAutomatesVehicle-Licensing-AdpLT2319 scored 0.838, which is also almost equal to 0.84, when rounded. The outcome of further two projects on ranking 6th and 7th also show that they are not far off then 0.84 i.e. z scored 0.828 and TrafficLicencingSysV4.0-AdpTR7531 scored 0.823. Thus, the only clearly selectable projects in this scenario are the SecuritySystemCompaniesV.3-AdpIT5981 and SmsSystemV1.0-AdpLT7823.

	Scenario 6	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.932
2	SmsSystemV1.0-AdpLT7823	0.913
3	NationalServiceAndFederalReserveSystem-AdpIT786	0.843
4	VisitorReceptionSystem-AdpIT431	0.84
5	KioskAutomatesVehicleLicensing-AdpLT2319	0.838
6	SmartLibraryWebsite-AdpIT7861	0.828
7	TrafficLicencingSysV4.0-AdpTR7531	0.823

5.3.1.17 Outcomes of Scenario 7 Projects Portfolio Data

This scenario considered another interesting distribution of priorities and the main emphasis has been again given to those factors that are related to the Operational

Continuity of an organisation. Moreover, sustainability was given the second most important priority. Moreover, while selecting Operational Continuity as the main factor, the portfolio managers also selected project Criticality, Efficiency Improvement and Technical Complexity (Fitness) as equally important. Consequently, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Most Important. Another important, change in this scenario was giving natural place to Project Commercial Value to minimize it effect on the portfolio selection; and therefore, it was defined as Medium Important. Finally, in complete contrast with previous scenario this scenario considers Completion and Planning as the Extremely Least Important Factors. The main interesting finding in this scenario was that the TrafficLicencingSysV4.0-AdpTR7531 project scored highest 0.929. In all of the previous scenarios TrafficLicencingSysV4.0-AdpTR7531 scored very low and never appeared as the top project. In the scenario, the remaining projects in top 5 did appeared within the top selection i.e. SecuritySystemCompaniesV.3-AdpIT5981 scored 0.885, SmsSystemV1.0-AdpLT7823 scored 0.859, NationalServiceAndFederalReserve-System-AdpIT786 scored 0.855 and KioskAutomatesVehicleLicensing-AdpLT2319 scored 0.853. Finally, this scenario also gave a clear outcome in terms of top most and top five selectable projects. The rest of the projects comparatively scored less with a large margin.

S. No	Scenario 7	Scores
1	TrafficLicencingSysV4.0-AdpTR7531	0.929
2	SecuritySystemCompaniesV.3-AdpIT5981	0.885
3	SmsSystemV1.0-AdpLT7823	0.859
4	NationalServiceAndFederalReserveSystem-AdpIT786	0.855
5	KioskAutomatesVehicleLicensing-AdpLT2319	0.853
6	VisitorReceptionSystem-AdpIT431	0.774
7	SmartLibraryWebsite-AdpIT7861	0.726

5.3.1.18 Outcomes of Scenario 8 Projects Portfolio Data

To further analyse the impact of sustainability (after scenario 4), in this scenario 8 sustainability was once again considered as the main priority to observe its impact as compared to the previous scenarios. Hence, in this scenario Economic Sustainability, Social Sustainability and Environment Sustainability were given the priorities as Extremely Most Important. Moreover, in contrast with scenario 4 where Project Commercial Value was given the least priority i.e. Extremely Less Important, this scenario considered Project Commercial Value at the second highest priority i.e. Most Important. Now to level the other factors with previous scenario and also to deal with rare situations where Financial Analysis and Protection from Threats and Risks are not as important as sustainability, in this scenario all these factors were defined Less Important. Similarly, this scenario considers Completion and Planning as the Extremely Least Important factors.

The major finding of this scenario is that despite switching the positions of Financial Analysis and Protection from Threats and Risks from Project Commercial Value; as compared with scenario 4, the top five projects remained the same i.e. SecuritySystemCompaniesV.3-AdpIT5981 scored 0.959, NationalServiceAnd-FederalReserveSystem-AdpIT786 scored 0.944, TrafficLicencingSysV4.0-

AdpTR7531 scored 0.94, SmsSystemV1.0-AdpLT7823 scored 0.94 and KioskAutomatesVehicleLicensing-AdpLT2319 scored 0.923. In comparison, these projects appeared in a different ranking order. However, this variation is quite ignorable as all these five projects scored very closely. Note the last five scoring projects in this scenario, all of them scored extremely low with a large margin. It is also important to note here that to naturalise the effect of financial constraints as well as project risks, in this scenario Financial Analysis, and Protection from Threats and Risks were given the priority as Medium Important. Thus, again practically found out at that taking sustainability as the Extremely Most Important factor does changes the portfolio selection outcomes to a large extant; whereas, changing the other priorities at the same time do not largely effect the overall portfolio outcomes.

S. No	Scenario 8	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.959
2	NationalServiceAndFederalReserveSystem-AdpIT786	0.944
3	TrafficLicencingSysV4.0-AdpTR7531	0.94
4	SmsSystemV1.0-AdpLT7823	0.94
5	KioskAutomatesVehicleLicensing-AdpLT2319	0.923
6	VisitorReceptionSystem-AdpIT431	0.708
7	SmartLibraryWebsite-AdpIT7861	0.687

5.3.1.19 Outcomes of Scenario 9 Projects Portfolio Data

This scenario enabled us to analyse the impact of sustainability by keeping it nearly as important as Project Commercial Value. This was done to test the argument given by the portfolio managers, that sometimes organisations are obliged to give Project Commercial Value as the main priority in a portfolio while also giving a high consideration to sustainability. Therefore, in this scenario Project Commercial Value was considered as the Extremely Most Important priority and all Economic Sustainability, Social Sustainability and Environment Sustainability were defined as Most Important.

The major finding of this scenario is that although Project Commercial Value was moved on the highest priority but kept sustainability related factors on priority against all other factors, the top five projects remained the same as of scenario 4 and 8. Thus, moving Project Commercial Value as top priority doesn't effected the portfolio if sustainability related factors were still considered on high priority than others. It is to be noted here that after discussion with portfolio manager, in this scenario the factors related to organisation operations and project complexly were naturalised by giving Medium Important priority to Criticality, Operational Continuity, Efficiency Improvement and Technical Complexity (Fitness) factors. Moreover, all other factors were given least priorities. So, both Completion (Success) and Planning were defined as Less Important, and the rest of the factors i.e. Financial Analysis and Protection from Threats and Risks has been defined as Extremely Less Important. Coming back to findings, all the top five projects did came in a different ranking order and this ranking is not ignorable as compared to scenario 8. This is mainly because the TrafficLicencingSysV4.0-AdpTR7531 project scored 0.955 and SecuritySystemCompaniesV.3-AdpIT5981 project scored 0.945, which are on a clear margin with rest of the projects. Thus, the portfolio could easily select the top two

projects instead of going to the top five, which are also selectable due to clear margins between project SmsSystemV1.0-AdpLT7823 scoring 0.864 at number five and VisitorReceptionSystem-AdpIT431 scoring 0.749 at number six.

S. No	Scenario 9	Scores
1	TrafficLicencingSysV4.0-AdpTR7531	0.955
2	SecuritySystemCompaniesV.3-AdpIT5981	0.945
3	NationalServiceAndFederalReserveSystem-AdpIT786	0.893
4	KioskAutomatesVehicleLicensing-AdpLT2319	0.873
5	SmsSystemV1.0-AdpLT7823	0.864
6	VisitorReceptionSystem-AdpIT431	0.749
7	SmartLibraryWebsite-AdpIT7861	0.738

5.3.1.20 Outcomes of Scenario 10 Projects Portfolio Data

This was the final scenario that considered the first scenario of projects. The main reason of specifying this scenario by the portfolio manager was to see the impact when all of the factors are given equally importance. This was necessary to not only see the outcome of such portfolio, but to also compare the outcomes with all the above scenarios. Therefore, in scenario 10 all Financial Analysis, Protection from Threats and Risks, Completion (Success), Planning, Criticality, Operational Continuity, Efficiency Improvement Technical Complexity (Fitness), Economic Sustainability, Social Sustainability, Environment Sustainability and Project Commercial Value were given Equally Important priority.

The major and most interesting finding of this scenario is that all top five scoring projects in this scenario remained the same as those scenarios where sustainability was considered as an important factor. The outcomes are SecuritySystemCompaniesV.3-AdpIT5981 scored 0.93, SmsSystemV1.0-AdpLT7823 scored 0.897, NationalServiceAndFederalReserveSystem-AdpIT786 scored 0.875, TrafficLicencingSysV4.0-AdpTR7531 scored 0.875, KioskAutomates-VehicleLicensing-AdpLT2319 scored 0.855 and VisitorReceptionSystem-AdpIT431 scored 0.807. By looking at the scores, this can be clearly noted that SecuritySystemCompaniesV.3-AdpIT5981 scored highest with clear margins. Moreover, there is also a clear gap in the scores of projects 5 and 6 and then from this portfolio top five projects can also be selected. In conclusion, having same resultant top five project; though in different orders, in all those scenarios where sustainability was either considered at higher or at equal priority with all factors provides great confidence to the project portfolio managers in selecting these projects for development.

S. No	Scenario 10	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.93
2	SmsSystemV1.0-AdpLT7823	0.897
3	NationalServiceAndFederalReserveSystem-AdpIT786	0.875
4	TrafficLicencingSysV4.0-AdpTR7531	0.875
5	KioskAutomatesVehicleLicensing-AdpLT2319	0.855
6	VisitorReceptionSystem-AdpIT431	0.807
7	SmartLibraryWebsite-AdpIT7861	0.791

5.3.2 Policy 2

The Policy 2 states "Gather the scores of top three ranked projects in all of the scenarios and then select the resultant top scoring projects".

This policy allows selecting the best three projects in all the scenarios. First, take the top three scoring project in each of the scenario and then combine the scores obtained by individual projects. It is to note here that if a project was not in the top 3 for a particular scenario then its score is considered as zero. This was done because only top 3 scoring projects are of interest and in each scenario. However, this constraint can be relaxed depending on the number of projects in a portfolio.

The main advantage of this policy is that it gives equal weightage to all the scenarios' rankings given by the portfolio managers. Thus, the portfolio managers are free to choose any number of top resultant projects. However, the case study organisation preferred to select between one to three top projects using this policy.

The following are the top three scoring projects in scenario 1:

S. No	Scenario 1	Scores
1	Security System Companies V.3- AdpIT5981	0.942
2	Sms System V1.0- AdpLT7823	0.92
3	Smart Library Website -AdpIT786	0.899

The following are the top three scoring projects in scenario 2:

S. No	Scenario 2	Scores
1	Security System Companies V.3-AdpIT5981	0.953
2	Sms System V1.0-AdpLT7823	0.934
3	Smart Library Website-AdpIT786	0.896

The following are the top three scoring projects in scenario 3:

S. No	Scenario 3	Scores
1	Security System Companies V.3-AdpIT5981	0.884
2	Traffic Licencing Sys V4.0 -AdpTR7531	0.876
3	Sms System V1.0- AdpLT7823	0.856

The following are the top three scoring projects in scenario 4:

S. No	Scenario 4	Scores
1	Sms System V1.0-AdpLT7823	0.963
2	Security System CompaniesV.3-AdpIT5981	0.953
3	National Service And Federal Reserve System-AdpIT786	0.943

The following are the top three scoring projects in scenario 5:

S. No	Scenario 5	Scores
1	Security System Companies V.3- AdpIT5981	0.959

2	Smart Library Website-AdpIT786	0.913
3	Visitor Reception System-AdpIT431	0.887

The following are the top three scoring projects in scenario 6:

S. No.	Scenario 6	Scores
1	SecuritySystemCompaniesV.3-AdpIT5981	0.932
2	SmsSystemV1.0-AdpLT7823	0.913
3	NationalServiceAndFederalReserveSystem-AdpIT786	0.843

The following are the top three scoring projects in scenario 7:

S. No	Scenario 7	Scores
1	Traffic Licencing Sys V4.0-AdpTR7531	0.929
2	Security System Companies V.3-AdpIT5981	0.885
3	Sms System V1.0-AdpLT7823	0.859

The following are the top three scoring projects in scenario 8:

S. No	Scenario 8	Scores
1	Security System CompaniesV.3-AdpIT5981	0.959
2	National Service And Federal Reserve System-AdpIT786	0.944
3	Traffic Licencing SysV4.0-AdpTR7531	0.94

The following are the top three scoring projects in scenario 9:

S. No	Scenario 9	Scores
1	Traffic Licencing SysV4.0-AdpTR7531	0.955
2	Security System CompaniesV.3-AdpIT5981	0.945
3	National Service And Federal Reserve System-AdpIT786	0.893

The following are the top three scoring projects in scenario 10:

S. No	Scenario 10	Scores
1	Security System CompaniesV.3-AdpIT5981	0.93
2	Sms SystemV1.0-AdpLT7823	0.897
3	National Service And Federal Reserve System-AdpIT786	0.875

In all of the above scenarios, the top three scoring projects were taken. It can be argued that why top 3, and why not top 1, 5 or 7 or even all? This is the number that has been decided after consultation with the portfolio managers. In the selected case study organisation, they are usually required to shortlist top three or top five projects by the top management depending on the available funding and number of projects in a portfolio. However, according to the portfolio managers of case study organisation is highly unlikely that more than 50% projects from a portfolio are considered for development at one point in time. The unfunded projects are reconsidered in the second scenario of project portfolio selection and so on.

The following table shows the complete calculation and outcomes of this policy. The calculation is straightforward as introduced above. In the first step, make note of all projects that appeared at top three in any scenario. In the second step, add the scores of those selected projects in all scenarios only if that project was in the top three projects. Thus, if a project was not in the top 3 for a scenario then put 0.

Practical Implementation of Policy 2

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
1	KioskAutomatesVehicleLicensing-AdpLT2319	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	NationalServiceAndFederalReserveSystem-AdpIT786	0.000	0.000	0.000	0.943	0.000	0.843	0.000	0.944	0.893	0.875	**4.498**
3	SecuritySystemCompaniesV.3-AdpIT5981	0.942	0.953	0.884	0.953	0.959	0.932	0.885	0.959	0.945	0.93	**9.342**
4	SmartLibraryWebsite-AdpIT7861	0.899	0.896	0.000	0.000	0.913	0.000	0.000	0.000	0.000	0.000	2.708
5	SmsSystemV1.0-AdpLT7823	0.92	0.934	0.856	0.963	0.000	0.913	0.859	0.000	0.000	0.897	**6.342**
6	TrafficLicencingSysV4.0-AdpTR7531	0.000	0.000	0.876	0.000	0.000	0.000	0.929	0.94	0.955	0.000	3.700
7	VisitorReceptionSystem-AdpIT431	0.000	0.000	0.000	0.000	0.887	0.000	0.000	0.000	0.000	0.000	0.887

The major finding of this policy implementation is getting very clear outcomes in terms of overall high scoring projects. The outcomes suggested that SecuritySystemCompaniesV.3-AdpIT5981 is the most favourable project. The second most favourable project is SmsSystemV1.0-AdpLT7823 that scored highest with a clear margin from rest of the projects. This is followed by the NationalServiceAndFederalReserveSystem-AdpIT786, TrafficLicencingSysV4.0-AdpTR7531, SmartLibraryWebsite-AdpIT7861 and VisitorReceptionSystem-AdpIT431, respectfully. Moreover, the KioskAutomatesVehicle Licensing-AdpLT2319 is appeared as the least favourable project. This is this project didn't appear at top three in any of the scenarios. The justification of selecting top 3 projects by the case study organisation has been already given above; however, other organisations should be deciding the top number of projects as per their funding and other constraints. In conclusion, this policy is not only giving an overall tool to select any number of top scoring projects in all scenarios, but it is also giving a list of those projects which are least favourable and must be considered in second and/or other scenarios.

5.3.3 Policy 3

The Policy 3 allows the calculation of *Median* and *Mode* of rankings for individual project in all scenarios as well as the calculation of *Mean* score. Here, the "ranking" is the order of projects in which they scored from highest to lowest. If there are seven projects in total, the top-scoring project is ranked at first and lowest scoring project is ranked as seven. The Policy 3 reads "*calculate the Median and Mode of rankings for individual projects and the Mean of project scores in all scenarios*". This policy gives a lot of flexibility to the decision makers to base their portfolio selection decision either of the *Mean, Median* or *Mode* of the ranking for individual projects in all scenarios.

Findings show that almost same projects got selected for both *Median* and *Mode* calculations. However, in the practical investigation, it was witnessed that calculating *Median* is more appropriate as compared to the *Mode*. This is because for dissimilar ranked values of all the projects, *Mode* cannot be calculated. Moreover, the *Mean* of individual project scores was also calculated in all scenarios to provide a conflict resolution mechanism when two projects score the similar *Median* or *Mode* value. So overall, this policy provides individual as well as combined mechanisms for project selection, where the *Mean* of projects scores can be considered for further analysis and decision-making. In the following sections, these findings are explained with the help of results, which have been obtained through the practical implementation of this policy.

To calculate the *Mean*, *Median* and *Mode* of rankings for individual project in all scenarios a spreadsheet tool was implemented for all the calculations. In the following table first all the projects are sorted alphabetically and then their rankings and scores are mentioned.

Policy 3 Spreadsheet – Sorted in alphabetical order, for all *Mean*, *Median* and *Mode* calculations

Alternatives	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
KioskAutomatesVehicleLicensing-AdpLT2319	6	0.83	6	0.83	6	0.82	4	0.92	7	0.80	5	0.84	5	0.85	5	0.92	4	0.87	5	0.86
NationalServiceAndFederalReserveSystem-AdpIT786	5	0.87	5	0.85	4	0.84	3	0.94	4	0.86	3	0.84	4	0.86	2	0.94	3	0.89	3	0.88
SecuritySystemCompaniesV.3-AdpIT5981	1	0.94	1	0.95	1	0.88	2	0.95	1	0.96	1	0.93	2	0.89	1	0.96	2	0.95	1	0.93
SmartLibraryWebsite-AdpIT7861	3	0.90	3	0.90	7	0.80	7	0.70	2	0.91	6	0.83	7	0.73	7	0.69	7	0.74	7	0.79
SmsSystemV1.0-AdpLT7823	2	0.92	2	0.93	3	0.86	1	0.96	5	0.85	2	0.91	3	0.86	4	0.94	5	0.86	2	0.90
TrafficLicencingSysV4.0-AdpTR7531	7	0.78	7	0.77	2	0.88	5	0.91	6	0.85	7	0.82	1	0.93	3	0.94	1	0.96	4	0.88
VisitorReceptionSystem-AdpIT431	4	0.89	4	0.89	5	0.83	6	0.73	3	0.89	4	0.84	6	0.77	6	0.71	6	0.75	6	0.81

The following data shows the resultant Rank *Median* of all the portfolio projects in all scenarios. Here Rank 1 means the highest priority and Rank 7 means the lowest priority. As shown in the following table, the project SecuritySystemCompaniesV.3-AdpIT5981 got the ranked *Median* value 1, followed by the SmsSystemV1.0-AdpLT7823 project that got ranked *Median* value 2.5 and the third highest project is NationalServiceAndFederalReserveSystem-AdpIT786 with a ranked *Median* value 3.5. For case study organisation, the selection of three top projects was carried out; however, other organizations are free to choose any number of top projects in each portfolio evaluation exercise.

Alternatives	Rank *Median*
KioskAutomatesVehicleLicensing-AdpLT2319	5
NationalServiceAndFederalReserveSystem-AdpIT786	3.5
SecuritySystemCompaniesV.3-AdpIT5981	1
SmartLibraryWebsite-AdpIT7861	7
SmsSystemV1.0-AdpLT7823	2.5
TrafficLicencingSysV4.0-AdpTR7531	4.5
VisitorReceptionSystem-AdpIT431	5.5

The following data shows the resultant Rank *Mode* of all the portfolio projects in all scenarios. Here Rank 1 means the highest priority and Rank 7 means the lowest priority. As stated in the following table the project SecuritySystemCompaniesV.3-AdpIT5981 got the ranked *Mode* value 1, followed by the SmsSystemV1.0-AdpLT7823 project that got ranked *Mode* value 2 and the third highest project is NationalService-AndFederalReserveSystem-AdpIT786 with a ranked *Mode* value 3. As this can be seen from the data, in both *Median* and *Mode* calculation same projects were appeared on the top and in a same order. One benefit could be argued here of using *Mode* over *Median* is that *Mode* gives discrete values so decisions making could be more straightforward.

Alternatives	Rank *Mode*
KioskAutomatesVehicleLicensing-AdpLT2319	5
NationalServiceAndFederalReserveSystem-AdpIT786	3
SecuritySystemCompaniesV.3-AdpIT5981	1
SmartLibraryWebsite-AdpIT7861	7
SmsSystemV1.0-AdpLT7823	2
TrafficLicencingSysV4.0-AdpTR7531	7
VisitorReceptionSystem-AdpIT431	6

The following table is comparing the outcome of both Rank *Median* and Rank *Mode* for all the projects. The very first finding here is that, in both *Median* and *Mode* calculation same projects were appeared on the top and in a same order. However,

there is one project TrafficLicencingSysV4.0-AdpTR7531 that in the case of Rank *Median* scored 4.5 and for Rank *Mode* scored 7. So, which one is correct and which one should be considered? By looking in the complete dataset as presented above, be have noticed that the Rank *Mode* score 7 for TrafficLicencingSysV4.0-AdpTR7531 doesn't reflect its clear position and in this case the *Median* score is more accurate and reliable. This gives us another finding that in terms of reliable results calculating Rank *Median* is more appropriate then Rank *Mode*.

Alternatives	*Median*	*Mode*
	Rank *Median*	Rank *Mode*
KioskAutomatesVehicleLicensing-AdpLT2319	5	5
NationalServiceAndFederalReserveSystem-AdpIT786	3.5	3
SecuritySystemCompaniesV.3-AdpIT5981	1	1
SmartLibraryWebsite-AdpIT7861	7	7
SmsSystemV1.0-AdpLT7823	2.5	2
TrafficLicencingSysV4.0-AdpTR7531	4.5	7
VisitorReceptionSystem-AdpIT431	5.5	6

Then, the *Mean* calculation for both project rankings and project scores were looked. The following datasets show the outcomes in terms of Total Rank, Total Score, *Mean* of Rank and *Mean* of Scores. Here once again the top three projects are SecuritySystemCompaniesV.3-AdpIT5981, SmsSystemV1.0-AdpLT7823 and National-ServiceAndFederalReserveSystem-AdpIT786, respectively. Moreover, this data also confirms that TrafficLicencingSysV4.0-AdpTR7531 is on position 4 instead of 7; and therefore, the above *Mode* outcome wasn't reliable. When comparing all the projects outcomes with Rank *Median*, it has been observed that both Rank *Mean* and Rank *Median* provided same results, which also matched to the outcomes produced by taking the *Mean* of scores.

Alternatives	Outcome		*Mean*	
	Total Rank	Total Score	*Mean* of Rank	*Mean* of Score
KioskAutomatesVehicleLicensing-AdpLT2319	53	8.545	5.3	0.8545
NationalServiceAndFederalReserveSystem-AdpIT786	36	8.77	3.6	0.877
SecuritySystemCompaniesV.3-AdpIT5981	13	9.342	1.3	0.9342
SmartLibraryWebsite-AdpIT7861	56	7.974	5.6	0.7974
SmsSystemV1.0-AdpLT7823	29	8.995	2.9	0.8995
TrafficLicencingSysV4.0-AdpTR7531	43	8.701	4.3	0.8701
VisitorReceptionSystem-AdpIT431	50	8.106	5	0.8106

In conclusion, the Policy 3 allows the calculation of *Mean*, *Median* and *Mode* of rankings as well as *Mean* of projects scores for individual project in all scenarios. This policy gives a lot of flexibility to the decision makers to base their portfolio selection decision either on either of the calculation method. However, above practical implementation has found out that calculating *Median* is more appropriate as

compared to the *Mode*. Moreover, calculating *Mean* can be used to verify the results and for conflict resolution or to carry out further deep analysis if two projects score the similar *Median* value.

5.3.4 Policy 4

This policy gave further flexibility to the decision makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean, Median* or *Mode* of individual projects. This has proved to be very useful when the portfolio decision makers perceive one or more scenarios as an organisational priority.

With respect to policy 3, this Policy 4 allowed incorporation of further priorities to individual scenarios. So, in addition to the calculation of *Mean, Median* and *Mode* of individual project rankings in all scenarios, the policy 4 allows prioritising the score of each scenario. For example, if a project had scored 0.4 initially in scenario one, it could be prioritised at 0.8 if its propriety is defined as 2 i.e. 0.4 * 2 = 0.8. Moreover, if the portfolio manager would like to exclude a scenario from the portfolio, then its priority can be defined as 0, the default priority is 1. Moreover, it was practically evaluated the effect of defining priority on projects rankings. For example, if a project was ranked at number 6 initially in a scenario one, it could be ranked at 2 if its propriety is defined as 3 i.e. 6/3 = 2. It is important to note here that in the case of prioritising score with multiply it with the priority value and in the case of *Mode* it is divided with the priority value.

To perform a practical application of the policy gathered all projects data was gathered (as in previous policy implementation). This data is then first used to calculate the *Mean, Median* and *Mode* of "rankings" for individual project in all scenarios. In the second case the data is used to calculate the *Mean, Median* and *Mode* of "scores" for individual project in all scenarios. Results and finings of defining priorities on "rankings" are discussed first. The portfolio policy-4 spreadsheet is equipped with priority definition to automatically calculate the impact of priority on rankings. In the following table first all the projects are sorted alphabetically and then their rankings are stored. Moreover, the top header is showing the mechanism of defining priority. The default priority is set to 1. There is no limit on defining a priority and any number can be specified. The spreadsheet tool automatically performs rest of the calculations.

Snapshot of Portfolio Policy 4 Rank Spreadsheet – Default priority is set to 1

Alternatives	S1	Priority	S2	Priority	S3	Priority	S4	Priority	S5	Priority	S6	Priority	S7	Priority	S8	Priority	S9	Priority	S10	Priority
		1		1		1		1		1		1		1		1		1		1
Prioritised Ranking	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
Alternatives / Projects	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank
KioskAutomatesVehicleLicensing-AdpLT2319	6	6.00	6	6.00	6	6.00	4	4.00	7	7.00	5	5.00	5	5.00	5	5.00	4	4.00	5	5.00
NationalServiceAndFederalReserveSystem-AdpIT786	5	5.00	5	5.00	4	4.00	3	3.00	4	4.00	3	3.00	4	4.00	2	2.00	3	3.00	3	3.00
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	1	1.00	1	1.00	2	2.00	1	1.00	1	1.00	2	2.00	1	1.00	2	2.00	1	1.00
SmartLibraryWebsite-AdpIT7861	3	3.00	3	3.00	7	7.00	7	7.00	2	2.00	6	6.00	7	7.00	7	7.00	7	7.00	7	7.00
SmsSystemV1.0-AdpLT7823	2	2.00	2	2.00	3	3.00	1	1.00	5	5.00	2	2.00	3	3.00	4	4.00	5	5.00	2	2.00
TrafficLicencingSysV4.0-AdpTR7531	7	7.00	7	7.00	2	2.00	5	5.00	6	6.00	7	7.00	1	1.00	3	3.00	1	1.00	4	4.00
VisitorReceptionSystem-AdpIT431	4	4.00	4	4.00	5	5.00	6	6.00	3	3.00	4	4.00	6	6.00	6	6.00	6	6.00	6	6.00

Snapshot of Portfolio Policy 4 Rank Spreadsheet – With priority definitions

Alternatives	S1	Priority	S2	Priority	S3	Priority	S4	Priority	S5	Priority	S6	Priority	S7	Priority	S8	Priority	S9	Priority	S10	Priority
		1		1		1		1		1		1		1		1		10		1
Prioritised Ranking	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
Alternatives / Projects	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank	Rank	Priority Rank
KioskAutomatesVehicleLicensing-AdpLT2319	6	6.00	6	6.00	6	6.00	4	4.00	7	7.00	5	5.00	5	5.00	5	5.00	4	0.40	5	5.00
NationalServiceAndFederalReserveSystem-AdpIT786	5	5.00	5	5.00	4	4.00	3	3.00	4	4.00	3	3.00	4	4.00	2	2.00	3	0.30	3	3.00
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	1	1.00	1	1.00	2	2.00	1	1.00	1	1.00	2	2.00	1	1.00	2	0.20	1	1.00
SmartLibraryWebsite-AdpIT7861	3	3.00	3	3.00	7	7.00	7	7.00	2	2.00	6	6.00	7	7.00	7	7.00	7	0.70	7	7.00
SmsSystemV1.0-AdpLT7823	2	2.00	2	2.00	3	3.00	1	1.00	5	5.00	2	2.00	3	3.00	4	4.00	5	0.50	2	2.00
TrafficLicencingSysV4.0-AdpTR7531	7	7.00	7	7.00	2	2.00	5	5.00	6	6.00	7	7.00	1	1.00	3	3.00	1	0.10	4	4.00
VisitorReceptionSystem-AdpIT431	4	4.00	4	4.00	5	5.00	6	6.00	3	3.00	4	4.00	6	6.00	6	6.00	6	0.60	6	6.00

***Median* of Prioritised Rank:** The following calculations show the effect on *Median* by defining priority 10 to scenario 9. It has been found that KioskAutomatesVehicleLicensing-AdpLT2319 was ranked higher than the VisitorReceptionSystem-AdpIT431. Whereas by applying the priority, the *Median* of Rank changed the state of two projects and VisitorReceptionSystem-AdpIT431 is ranked higher than the KioskAutomatesVehicleLicensing-AdpLT2319 project. However, it has been observed that defining priority and calculating *Median* may not be a correctly workable solution. This is especially true in the cases of changing priority of only one scenario and if the project was already scoring low or high. In such a case, the change won't be reflected in the *Median* calculation and the middle scoring project would still appear as favourite in the resultant portfolio.

Alternatives Prioritised Ranking	Priority **1**	Priority **1**	Priority **1**	Priority **1**	Priority **1**	Priority **1**	Priority **1**	Priority **1**	Priority **10**	Priority **1**
Alternatives / Projects	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank
KioskAutomatesVehicleLicensing-AdpLT2319	6.00	6.00	6.00	4.00	7.00	5.00	5.00	5.00	0.40	5.00
NationalServiceAndFederalReserveSystem-AdpIT786	5.00	5.00	4.00	3.00	4.00	3.00	4.00	2.00	0.30	3.00
SecuritySystemCompaniesV.3-AdpIT5981	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	0.20	1.00
SmartLibraryWebsite-AdpIT7861	3.00	3.00	7.00	7.00	2.00	6.00	7.00	7.00	0.70	7.00
SmsSystemV1.0-AdpLT7823	2.00	2.00	3.00	1.00	5.00	2.00	3.00	4.00	0.50	2.00
TrafficLicencingSysV4.0-AdpTR7531	7.00	7.00	2.00	5.00	6.00	7.00	1.00	3.00	0.10	4.00
VisitorReceptionSystem-AdpIT431	4.00	4.00	5.00	6.00	3.00	4.00	6.00	6.00	0.60	6.00

Median	
Rank *Median*	**Prioritised Rank *Median***
5	5.00
3.5	3.50
1	1.00
7	6.50
2.5	2.00
4.5	4.50
5.5	4.50

***Mode* of Prioritised Rank:** The following calculations show the effect on *Mode* by defining priority 10 to scenario 9. It has been found that originally NationalServiceAndFederalReserveSystem-AdpIT786 was having Rank *Mode* 3, whereas by applying the priority the *Mode* of Rank changed to 4 for the same project. This has been already established above (in Policy 3) that calculating *Mode* for project ranking is not a reliable solution.

Alternatives	Priority 1	Priority 1	Priority 1	Priority 1	Priority 1	Priority 1	Priority 1	Priority 1	Priority 10	Priority 1
Prioritised Ranking										
Alternatives / Projects	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank	Priority Rank
KioskAutomatesVehicleLicensing-AdpLT2319	6.00	6.00	6.00	4.00	7.00	5.00	5.00	5.00	0.40	5.00
NationalServiceAndFederalReserveSystem-AdpIT786	5.00	5.00	4.00	3.00	4.00	3.00	4.00	2.00	0.30	3.00
SecuritySystemCompaniesV.3-AdpIT5981	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	0.20	1.00
SmartLibraryWebsite-AdpIT7861	3.00	3.00	7.00	7.00	2.00	6.00	7.00	7.00	0.70	7.00
SmsSystemV1.0-AdpLT7823	2.00	2.00	3.00	1.00	5.00	2.00	3.00	4.00	0.50	2.00
TrafficLicencingSysV4.0-AdpTR7531	7.00	7.00	2.00	5.00	6.00	7.00	1.00	3.00	0.10	4.00
VisitorReceptionSystem-AdpIT431	4.00	4.00	5.00	6.00	3.00	4.00	6.00	6.00	0.60	6.00

Mode	
Rank *Mode*	**Prioritised Rank *Mode***
5	5
3	4
1	1
7	7
2	2
7	7
6	6

The following datasets show the complete picture of *Median*, *Mode*l and *Mean* calculations of the cases discussed above. After detailed analysis it is also observed that defining priority to ranks is not an ideal solution all the times. This is mainly because it is not considering the actual scores of projects; and thus, cannot tell how closely two or more projects are scoring in a portfolio after priority definitions. Therefore, priorities to project scores are implemented and then their *Mean*, *Median* and *Mode* are calculated for individual project in all scenarios, which are discussed below.

Alternatives Prioritised Ranking	***Median***		***Mode***		**Outcome**		***Mean***	
Alternatives / Projects	**Rank *Median***	**Prioritised Rank *Median***	**Rank *Mode***	**Prioritised Rank *Mode***	Total Rank	**Prioritised Total Rank**	***Mean* of Rank**	***Mean* of Prioritised Rank**
KioskAutomatesVehicleLicensing-AdpLT2319	**5**	**5.00**	**5**	**5**	53	49.40	5.3	4.94
NationalServiceAndFederalReserveSystem-AdpIT786	**3.5**	**3.50**	**3**	**4**	36	33.30	3.6	3.33
SecuritySystemCompaniesV.3-AdpIT5981	**1**	**1.00**	**1**	**1**	13	11.20	1.3	1.12
SmartLibraryWebsite-AdpIT7861	**7**	**6.50**	**7**	**7**	56	49.70	5.6	4.97
SmsSystemV1.0-AdpLT7823	**2.5**	**2.00**	**2**	**2**	29	24.50	2.9	2.45
TrafficLicencingSysV4.0-AdpTR7531	**4.5**	**4.50**	**7**	**7**	43	42.10	4.3	4.21
VisitorReceptionSystem-AdpIT431	**5.5**	**4.50**	**6**	**6**	50	44.60	5	4.46

To perform a practical application of the policy 8 with scores the projects data is used to calculate the *Mean*, *Median* and *Mode* of "scores" for individual project in all scenarios. The portfolio policy 4 spreadsheet is then further equipped with priority definition to automatically calculate the impact of priority on score. In the following table first all the projects are sorted alphabetically and then their scores are stored. Moreover, the top header is showing the mechanism of defining priority. The default priority is set to 1. There is no limit on defining a priority and any number can be specified. The spreadsheet tool automatically performs rest of the calculations. As deliberated in the start of this section, if a project had scored 0.4 initially in scenario one, it could be prioritised at 0.8 if its propriety is defined as 2 i.e. 0.4 * 2 = 0.8. Moreover, if the portfolio manager would like to exclude a scenario from the portfolio, then they can define its priority as 0.

Snapshot of Portfolio Policy 4 Scores Spreadsheet – default priority

Alternatives	Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1	
Prioritised Scores	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
Alternatives / Projects	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score
KioskAutomatesVehicleLicensing-AdpLT2319	0.83	0.83	0.83	0.83	0.82	0.82	0.92	0.92	0.80	0.80	0.84	0.84	0.85	0.85	0.92	0.92	0.87	0.87	0.86	0.86
NationalServiceAndFederalReserveSystem-AdpIT786	0.87	0.87	0.85	0.85	0.84	0.84	0.94	0.94	0.86	0.86	0.84	0.84	0.86	0.86	0.94	0.94	0.89	0.89	0.88	0.88
SecuritySystemCompaniesV.3-AdpIT5981	0.94	0.94	0.95	0.95	0.88	0.88	0.95	0.95	0.96	0.96	0.93	0.93	0.89	0.89	0.96	0.96	0.95	0.95	0.93	0.93
SmartLibraryWebsite-AdpIT7861	0.90	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.91	0.91	0.83	0.83	0.73	0.73	0.69	0.69	0.74	0.74	0.79	0.79
SmsSystemV1.0-AdpLT7823	0.92	0.92	0.93	0.93	0.86	0.86	0.96	0.96	0.85	0.85	0.91	0.91	0.86	0.86	0.94	0.94	0.86	0.86	0.90	0.90
TrafficLicencingSysV4.0-AdpTR7531	0.78	0.78	0.77	0.77	0.88	0.88	0.91	0.91	0.85	0.85	0.82	0.82	0.93	0.93	0.94	0.94	0.96	0.96	0.88	0.88
VisitorReceptionSystem-AdpIT431	0.89	0.89	0.89	0.89	0.83	0.83	0.73	0.73	0.89	0.89	0.84	0.84	0.77	0.77	0.71	0.71	0.75	0.75	0.81	0.81

Snapshot of Portfolio Policy 4 Scores Spreadsheet –priority definitions

Alternatives	Priority	Priority	Priority	Priority	Priority	Priority	Priority	Priority	Priority	Priority
	1	1	1	1	1	1	1	1	12	1
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Prioritised Score										
Alternatives / Projects	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score
KioskAutomatesVehicleLicensing-AdpLT2319	0.83	0.83	0.83	0.83	0.82	0.82	0.92	0.92	0.80	0.80	0.84	0.84	0.85	0.85	0.92	0.92	0.87	10.48	0.86	0.86
NationalServiceAndFederalReserveSystem-AdpIT786	0.87	0.87	0.85	0.85	0.84	0.84	0.94	0.94	0.86	0.86	0.84	0.84	0.86	0.86	0.94	0.94	0.89	10.72	0.88	0.88
SecuritySystemCompaniesV.3-AdpIT5981	0.94	0.94	0.95	0.95	0.88	0.88	0.95	0.95	0.96	0.96	0.93	0.93	0.89	0.89	0.96	0.96	0.95	11.34	0.93	0.93
SmartLibraryWebsite-AdpIT7861	0.90	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.91	0.91	0.83	0.83	0.73	0.73	0.69	0.69	0.74	8.86	0.79	0.79
SmsSystemV1.0-AdpLT7823	0.92	0.92	0.93	0.93	0.86	0.86	0.96	0.96	0.85	0.85	0.91	0.91	0.86	0.86	0.94	0.94	0.86	10.37	0.90	0.90
TrafficLicencingSysV4.0-AdpTR7531	0.78	0.78	0.77	0.77	0.88	0.88	0.91	0.91	0.85	0.85	0.82	0.82	0.93	0.93	0.94	0.94	0.96	11.46	0.88	0.88
VisitorReceptionSystem-AdpIT431	0.89	0.89	0.89	0.89	0.83	0.83	0.73	0.73	0.89	0.89	0.84	0.84	0.77	0.77	0.71	0.71	0.75	8.99	0.81	0.81

***Mean* of Prioritised Score:** The following calculations show the effect on defining priority 12 on the scores of scenario 9. It has been found that in the original calculations without priority, SecuritySystemCompaniesV.3-AdpIT5981project had received the higher *Mean* score of 0.93, followed by the SmsSystemV1.0-AdpLT7823 project that scored 0.90, NationalServiceAndFederalReserveSystem-AdpIT786 scored 0.88, TrafficLicencingSysV4.0-AdpTR7531 scored 0.87 and on number 5th was the KioskAutomatesVehicleLicensing-AdpLT2319 that scored 0.85. Whereas, by applying the priority and then calculating the *Mean* of scores changed the state of two projects and now TrafficLicencingSysV4.0-AdpTR7531 moved from fourth position to second position and similarly the StatisticsPortsSecuritySystem-AdpLT7801 project moved from second to fourth position. The rest of the portfolio hierarchy remained the same. The benefit of defining priority on scores can be observed here; moreover, by looking at the final prioritised *Mean* score and difference of score between each project, portfolio managers can also evaluate how close they are and then make informed decision accordingly.

Alternatives	Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 12		Priority 1			*Mean*	
Prioritised Score	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10				
Alternatives / Projects	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score		Score *Mean*	Prioritised *Mean* Score	
KioskAutomatesVehicleLicensing-AdpLT2319	0.83	0.83	0.83	0.83	0.82	0.82	0.92	0.92	0.80	0.80	0.84	0.84	0.85	0.85	0.92	0.92	0.87	10.48	0.86	0.86	5th	0.85	1.81	5th
NationalServiceAndFederalReserveSystem-AdpIT786	0.87	0.87	0.85	0.85	0.84	0.84	0.94	0.94	0.86	0.86	0.84	0.84	0.86	0.86	0.94	0.94	0.89	10.72	0.88	0.88	3rd	0.88	1.86	3rd
SecuritySystemCompaniesV.3-AdpIT5981	0.94	0.94	0.95	0.95	0.88	0.88	0.95	0.95	0.96	0.96	0.93	0.93	0.89	0.89	0.96	0.96	0.95	11.34	0.93	0.93	1st	0.93	1.97	1st
SmartLibraryWebsite-AdpIT7861	0.90	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.91	0.91	0.83	0.83	0.73	0.73	0.69	0.69	0.74	8.86	0.79	0.79		0.80	1.61	
SmsSystemV1.0-AdpLT7823	0.92	0.92	0.93	0.93	0.86	0.86	0.96	0.96	0.85	0.85	0.91	0.91	0.86	0.86	0.94	0.94	0.86	10.37	0.90	0.90	2nd	0.90	1.85	4th
TrafficLicencingSysV4.0-AdpTR7531	0.78	0.78	0.77	0.77	0.88	0.88	0.91	0.91	0.85	0.85	0.82	0.82	0.93	0.93	0.94	0.94	0.96	11.46	0.88	0.88	4th	0.87	1.92	2nd
VisitorReceptionSystem-AdpIT431	0.89	0.89	0.89	0.89	0.83	0.83	0.73	0.73	0.89	0.89	0.84	0.84	0.77	0.77	0.71	0.71	0.75	8.99	0.81	0.81		0.81	1.63	

***Mode* of Prioritised Score:** The following calculations show the *Mode* of Score calculation and the effect on *Mode* after priority definition. As it can be seen that it is not possible to calculate *Mode* of score values. This is because mostly the projects scores consist of distinct values and they remain distinct even after applying priority. This has been already established in policy 3 that calculating *Mode* for project rankings is not a reliable solution. Here, another finding has been made that calculating *Mode* for project scores is not even a workable solution due to N/A i.e. not applicability of *Mode* calculations.

Alternatives	Priority		Priority		Priority		Priority		Priority		Priority		Priority		Priority		Priority		Priority		Priority		*Mode*	
	1		1		1		1		1		1		1		1		1		12		1			
Prioritised Score	S1		S2		S3		S4		S5		S6		S7		S8		S9				S10			
Alternatives / Projects	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score *Mode*	Prioritised Score *Mode*
KioskAutomatesVehicleLicensing-AdpLT2319	0.83	0.83	0.83	0.83	0.82	0.82	0.92	0.92	0.80	0.80	0.84	0.84	0.85	0.85	0.92	0.92	0.87	10.48	0.86	0.86	0.923	0.923
NationalServiceAndFederalReserveSystem-AdpIT786	0.87	0.87	0.85	0.85	0.84	0.84	0.94	0.94	0.86	0.86	0.84	0.84	0.86	0.86	0.94	0.94	0.89	10.72	0.88	0.88	#N/A	#N/A
SecuritySystemCompaniesV.3-AdpIT5981	0.94	0.94	0.95	0.95	0.88	0.88	0.95	0.95	0.96	0.96	0.93	0.93	0.89	0.89	0.96	0.96	0.95	11.34	0.93	0.93	0.953	0.953
SmartLibraryWebsite-AdpIT7861	0.90	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.91	0.91	0.83	0.83	0.73	0.73	0.69	0.69	0.74	8.86	0.79	0.79	#N/A	#N/A
SmsSystemV1.0-AdpLT7823	0.92	0.92	0.93	0.93	0.86	0.86	0.96	0.96	0.85	0.85	0.91	0.91	0.86	0.86	0.94	0.94	0.86	10.37	0.90	0.90	#N/A	#N/A
TrafficLicencingSysV4.0-AdpTR7531	0.78	0.78	0.77	0.77	0.88	0.88	0.91	0.91	0.85	0.85	0.82	0.82	0.93	0.93	0.94	0.94	0.96	11.46	0.88	0.88	#N/A	#N/A
VisitorReceptionSystem-AdpIT431	0.89	0.89	0.89	0.89	0.83	0.83	0.73	0.73	0.89	0.89	0.84	0.84	0.77	0.77	0.71	0.71	0.75	8.99	0.81	0.81	#N/A	#N/A

***Median* of Prioritised Score:** The following calculations show the effect on defining priority 12 on the scores of scenario 9 and then the calculation of *Median* has been carried out. As it can be seen from the resultant calculations, there is no major effect on the portfolio before and after the application of *Median*. As per the definition of *Median*, it is the value separating the higher half of a data sample, a population, or a probability distribution, from the lower half. Thus, even if priority is applied to one of the scenarios, it may not affect the *Median* outcome. However, it may possible to get useful results if most of the scenarios are prioritised but it is not always the case. Thus, it is not useful to calculate *Median* when defining priorities to specific scenarios in policy 4.

Alternatives	Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 1		Priority 12		Priority 1				
	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10				
Prioritised Score																							
Alternatives / Projects	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score	Score	Priority Score		Median Score Median	Median Prioritised Score Median	
KioskAutomatesVehicleLicensing-AdpLT2319	0.83	0.83	0.83	0.83	0.82	0.82	0.92	0.92	0.80	0.80	0.84	0.84	0.85	0.85	0.92	0.92	0.87	10.48	0.86	0.86		0.85	0.85	
NationalServiceAndFederalReserveSystem-AdpIT786	0.87	0.87	0.85	0.85	0.84	0.84	0.94	0.94	0.86	0.86	0.84	0.84	0.86	0.86	0.94	0.94	0.89	10.72	0.88	0.88	4th	0.86	0.86	4th
SecuritySystemCompaniesV.3-AdpIT5981	0.94	0.94	0.95	0.95	0.88	0.88	0.95	0.95	0.96	0.96	0.93	0.93	0.89	0.89	0.96	0.96	0.95	11.34	0.93	0.93	1st	0.94	0.95	1st
SmartLibraryWebsite-AdpIT7861	0.90	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.91	0.91	0.83	0.83	0.73	0.73	0.69	0.69	0.74	8.86	0.79	0.79		0.79	0.81	
SmsSystemV1.0-AdpLT7823	0.92	0.92	0.93	0.93	0.86	0.86	0.96	0.96	0.85	0.85	0.91	0.91	0.86	0.86	0.94	0.94	0.86	10.37	0.90	0.90	2nd	0.91	0.92	2nd
TrafficLicencingSysV4.0-AdpTR7531	0.78	0.78	0.77	0.77	0.88	0.88	0.91	0.91	0.85	0.85	0.82	0.82	0.93	0.93	0.94	0.94	0.96	11.46	0.88	0.88	3rd	0.88	0.88	3rd
VisitorReceptionSystem-AdpIT431	0.89	0.89	0.89	0.89	0.83	0.83	0.73	0.73	0.89	0.89	0.84	0.84	0.77	0.77	0.71	0.71	0.75	8.99	0.81	0.81		0.82	0.84	

Overall, the policy 4 has been implemented to provide further flexibility to the decision makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean, Median* or *Mode* of individual projects. After implementing various scenarios, it has been observed that defining priority to project ranking is not an ideal solution. This is mainly because ranks do not reflect the actual scores of projects; and thus, cannot tell how closely two or more projects are scoring in a portfolio after priority definitions. Therefore, priorities are implemented to project scores and then calculated their *Mean, Median* and *Mode* for individual project in all scenarios. In the case of defining priority on projects rankings projects ranks were divided with the priority value, and in the case of prioritising score project scores were multiplied with the priority value. In terms of defining priorities to project scores, it has been observed that *Mean* calculations gave the most useful mechanism to see the effect of prioritisation. Whereas, the *Mode* calculations failed to provide any useful outcomes, as the projects scores usually consist of distinct values and they remain distinct even after applying priority. In relation to *Median*, no major effect on the portfolio before and after the application of *Median* was noted especially when only one of the scenarios was prioritised. Thus, it can be concluded that for policy 4 when defining priorities to individual scenarios, taking *Mean* of prioritised scores is the suitable as compared to *Median* and *Mode*.

5.3.5 Policy 5

The case study organisation in this research was having multi-dimensional attributes towards environment, social and economic sustainability. To provide sustainability related portfolio decision making, a rigorous sustainability analysis was needed both at the time of project proposal formulation and project portfolio evaluation. In this regard, the Policies 5, 6 and 7 were developed and implemented. This was done to perform further sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of the sustainably factors that likely to impact, either positively or negatively.

The policy 5 states: *"select the top projects by considering Economic sustainability as the main optimisation factor".* When in a portfolio Economic sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. This policy permitted to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in a portfolio of projects.

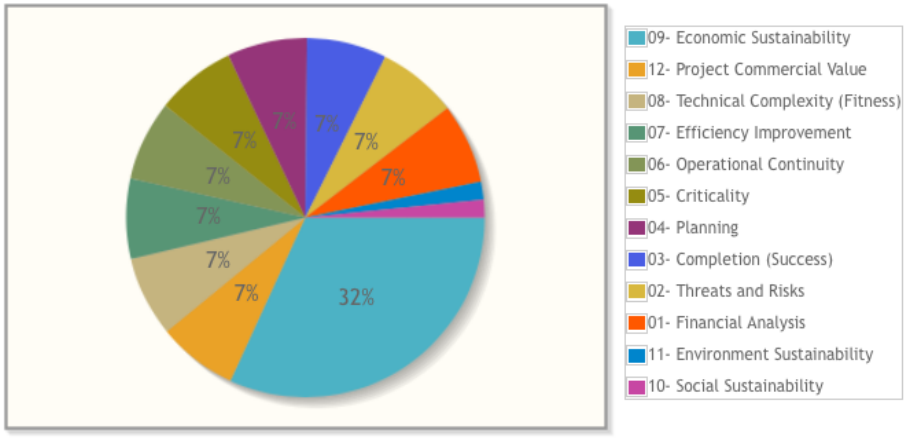
The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Sustainability Specific Scenario 11				
Economic Sustainability		Financial Analysis		Social Sustainability
		Protection from Threats and Risks;		Environment Sustainability
		Completion (Success)		

Planning
Criticality
Operational Continuity
Efficiency Improvement
Technical Complexity (Fitness)
Project Commercial Value

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions. As it can be seen that Economic Sustainability received 31.8 value as compared to the Social and Environment Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

CRITERIA	PRIORITY
01 - Financial Analysis	7.2
02 - Threats and Risks	7.2
03 - Completion (Success)	7.2
04 - Planning	7.2
05 - Criticality	7.2
06 - Operational Continuity	7.2
07 - Efficiency Improvement	7.2
08 - Technical Complexity (Fitness)	7.2
09 - Economic Sustainability	31.8
10 - Social Sustainability	1.6
11 - Environment Sustainability	1.6
12 - Project Commercial Value	7.2



To perform a practical application of the policy all projects data is gathered, processed and the results are presented in the following table. The SecuritySystemCompaniesV.3-AdpIT5981 clearly scored the highest score of 0.946 with a large margin from all the other projects. So, if the portfolio managers need to select one top project than they clearly got a choice. Further results show that SmsSystemV1.0-AdpLT7823 project scored 0.91, whereas both NationalServiceAndFederalReserveSystem-AdpIT786 project and TrafficLicencing-SysV4.0-AdpTR7531 project scored the same 0.892. In this scenario, the top four projects can be selected as both 3rd and 4th projects scored the same. Moreover, there is not much gap between the scores of top four projects and the

KioskAutomatesVehicleLicensing-AdpLT2319 project that scored 0.874. Comparatively, the rest of the projects scored very low and this policy has brought up 5 top projects supporting economic sustainability. In the policy 8, a combined effect of all sustainability related factors through rankings is analysed, which is presented in the later sections.

Alternatives / Projects	SCORE
SecuritySystemCompaniesV.3-AdpIT5981	**0.946**
SmsSystemV1.0-AdpLT7823	0.91
NationalServiceAndFederalReserveSystem-AdpIT786	0.892
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.761
SmartLibraryWebsite-AdpIT7861	0.745

5.3.6 Policy 6

The consideration of *Social* sustainability in project selection is to ensure that project maintains social stability. In addition, it is evaluated that the project considered issues related to the level and degree of acceptability of a project to the community, the local representatives, the executing agency etc. The policy 6 is defined as: *"select the top three projects by considering Social sustainability as the main optimisation factor".*

When in a portfolio *Social* sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in this portfolio of projects. Overall, this policy allowed to priorities those projects that have positive societal implications or their negative impacts on social stability are either avoided or mitigated during the life of the project.

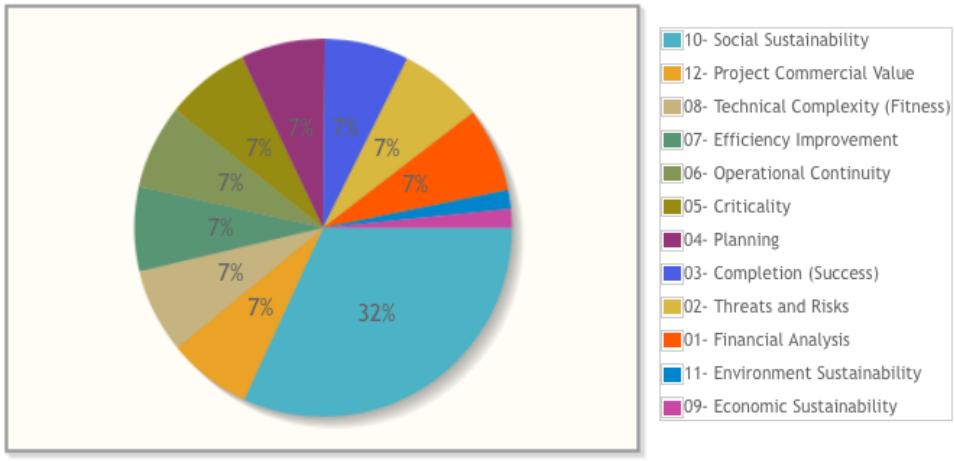
The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Sustainability Specific Scenario 12				
Social Sustainability		Financial Analysis		Economic Sustainability
		Protection from Threats and Risks;		Environment Sustainability
		Completion (Success)		
		Planning		
		Criticality		
		Operational Continuity		
		Efficiency Improvement		
		Technical Complexity (Fitness)		

Project Commercial Value

The following scores were obtained by applying the pair-wise comparison using Analytic Hierarchy Process (AHP) technique on the above priority distributions. As it can be seen that Social Sustainability received 31.8 value as compared to the Economic and Environment Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

CRITERIA	PRIORITY
01 - Financial Analysis	7.2
02 - Threats and Risks	7.2
03 - Completion (Success)	7.2
04 - Planning	7.2
05 - Criticality	7.2
06 - Operational Continuity	7.2
07 - Efficiency Improvement	7.2
08 - Technical Complexity (Fitness)	7.2
09 - Economic Sustainability	1.6
10 - Social Sustainability	31.8
11 - Environment Sustainability	1.6
12 - Project Commercial Value	7.2



A practical application of this policy has been conducted and the results are presented in the table below. The outcome of this policy 6 is not very different than the policy 5 where Economic Sustainability was given the highest priority. Practical application of this policy showed that although projects have scored slightly differently when Social and Economic Sustainability were interchangeably considered on higher priority, the top projects remained in a similar sequence. However, there is a difference in resultant sequence in the last two projects in the portfolio. However, the results are quite different when Environment Sustainability is considered as main factor, which is discussed in the next section.

In relation to the application of policy 6, the SecuritySystemCompaniesV.3-AdpIT5981 scored the highest 0.946, the SmsSystemV1.0-AdpLT7823 project scored 0.91, whereas both NationalServiceAndFederalReserveSystem-AdpIT786 project and

TrafficLicencingSysV4.0-AdpTR7531 project scored the same 0.892. In this scenario, the top four projects can be selected as both 3rd and 4th projects scored the same. Moreover, there is not much gap between the scores of top four projects and the KioskAutomatesVehicleLicensing-AdpLT2319 that scored 0.874. Comparatively, the rest of the projects scored very low and this policy has also brought up 5 top projects supporting economic sustainability.

Alternatives / Projects	SCORE
SecuritySystemCompaniesV.3-AdpIT5981	**0.946**
SmsSystemV1.0-AdpLT7823	0.91
NationalServiceAndFederalReserveSystem-AdpIT786	0.892
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.773
SmartLibraryWebsite-AdpIT7861	0.762

5.3.7 Policy 7

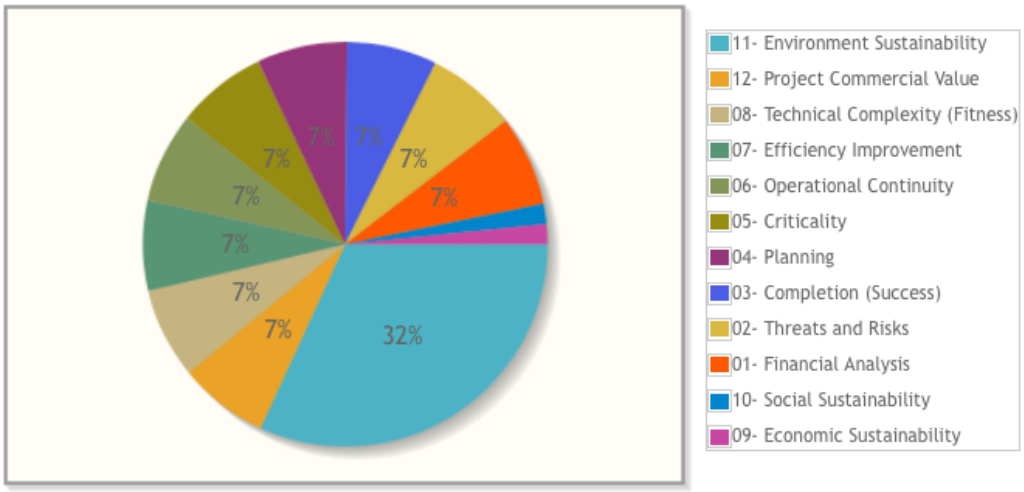
The policy 7 was developed to select projects based on the *Environmental* sustainability. The policy 7 stated: *"select the top three projects by considering Environmental sustainability as the main optimisation factor".* When in a portfolio Environmental sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in a portfolio of projects. Overall, this policy allowed to priorities those projects that have positive *environmental* implications or their negative impacts on *environment* are either avoided or mitigated during the life of the project. The following Table shows the distribution of criteria into different levels of priority.

Extremely Most Important	Most Important	Medium Important	Less Important	Extremely Less Important
Sustainability Specific Scenario 13				
Environment Sustainability		Financial Analysis		Social Sustainability
		Protection from Threats and Risks;		Economic Sustainability
		Completion (Success)		
		Planning		
		Criticality		
		Operational Continuity		
		Efficiency Improvement		
		Technical Complexity (Fitness)		
		Project Commercial Value		

The following scores were obtained by applying the pair-wise comparison using AHP technique on the above priority distributions. As it can be seen that Environment Sustainability received 31.8 value as compared to the Economic and Social

Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

CRITERIA	PRIORITY
01 - Financial Analysis	7.2
02 - Threats and Risks	7.2
03 - Completion (Success)	7.2
04 - Planning	7.2
05 - Criticality	7.2
06 - Operational Continuity	7.2
07 - Efficiency Improvement	7.2
08 - Technical Complexity (Fitness)	7.2
09 - Economic Sustainability	1.6
10 - Social Sustainability	1.6
11 - Environment Sustainability	**31.8**
12 - Project Commercial Value	7.2



The outcomes of this policy 7 are interestingly not like the policy 5 and 6 where Economic and Social Sustainability were given the highest priority. In relation to the application of policy 7, the SmsSystemV1.0-AdpLT7823 scored the highest 0.91 score, which was not the case in policies 5 and 6. In both policies 5 and 6, the SecuritySystemCompaniesV.3-AdpIT5981 scored the highest 0.946. However, in this policy when the Environment Sustainability is given the highest priority and both Economic and Social Sustainability are given the lowest priority, both the SmsSystemV1.0-AdpLT7823 project scored 0.91, whereas both NationalServiceAndFederalReserveSystem-AdpIT786 and SecuritySystem-CompaniesV.3-AdpIT5981 projects scored the same 0.91. Therefore, in this case the results are altogether changed due to the changes in sustainability factors' prioritisations. Moreover, both NationalServiceAndFederalReserveSystem-AdpIT786 and TrafficLicencingSysV4.0-AdpTR7531 projects scored the equal 0.892 score. In this scenario, the any of top two or four projects can be selected as both 3rd and 4th projects also scored the same. Furthermore, there is not much gap between the scores of top four projects and the KioskAutomatesVehicleLicensing-AdpLT2319 that

scored 0.874 and came on 5th position. Comparatively, the rest of the projects scored very low. Furthermore, when comparing policy 5 and policy 6 it have been found that the outcome is also different for the rest of the projects.

Alternatives / Projects	SCORE
SmsSystemV1.0-AdpLT7823	0.91
SecuritySystemCompaniesV.3-AdpIT5981	0.91
NationalServiceAndFederalReserveSystem-AdpIT786	0.892
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.8
SmartLibraryWebsite-AdpIT7861	0.766

Other findings in relation to this policy conform to previous findings i.e.: (1) projects scoring poor in terms of *Economic sustainability* mostly also scored poor for *Social sustainability*, and vice versa; and (2) projects scoring poor in terms of *Environmental sustainability* most of the times also scored poor for both *Economic* and *Social* sustainability, and vice versa. Although, there is no direct relationship between various sustainability factors, it is observed that one factors sometime influence other; for example, in some projects the negative *Environmental* impacts may yield benefits at a reduced rate depending on the extent of environmental costs, such negative impacts may in fact contribute to the net losses to the economy. Thus, to see a combined effect of *Economic*, Social and *Environmental sustainability* on a portfolio of projects Policy 8 is developed and implemented, which presented in the next section of this chapter.

5.3.8 Policy 8

To observe a combined effect of *Economic*, *Social* and *Environmental* sustainability factors on a portfolio of projects Policy 8 is implemented. In this policy, three scenarios are considered. The Policy 8 stats that “calculate the Mean, Median and Mode of individual project rankings and Mean of project score in three scenarios where in each of them Economic, Social and Environmental sustainability was considered as the main optimisation factor, respectively". In addition, incorporating further priority are also allowed to any of the scenarios. The prioritisation aspect of this policy is discussed later in this section. This policy gave a worthy control to the decision makers to base their portfolio selection decision by giving different priorities to Economic, Social and Environmental optimisation factor scenarios.

Scenarios implementations show both *Mean* and *Median* calculations of projects rankings gave reliable outcomes as compared to the *Mode* calculations, as for dissimilar ranked project values in various scenarios *Mode* cannot be calculated. Moreover, the *Mean* of individual project scores based on Policy 8 are considered to provide a conflict resolution mechanism when two projects score the similar *Median* value. So overall, this policy 8 provides individual as well as combined mechanism for project selection where sustainability has been considered as the main optimisation factor, and the *Mean* of scores can be considered for further deep

analysis and decision-making. Note that the prioritisation aspect of this policy is discussed later in this section.

The following are outcomes of practical implementation of this policy. In the following table, the top three scoring projects are highlighted when Economic Sustainability has been considered as the main optimisation factor.

Top three projects by considering **Economic Sustainability** as the main optimisation factor.

Alternatives / Projects	SCORE
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
NationalServiceAndFederalReserveSystem-AdpIT786	**0.892**
SecuritySystemCompaniesV.3-AdpIT5981	**0.946**
SmartLibraryWebsite-AdpIT7861	0.745
SmsSystemV1.0-AdpLT7823	**0.91**
TrafficLicencingSysV4.0-AdpTR7531	0.892
VisitorReceptionSystem-AdpIT431	0.761

In the following table top three scoring projects are highlighted when Social Sustainability has been considered as the main optimisation factor.

Top three projects by considering Social Sustainability as the main optimisation factor

Alternatives / Projects	SCORE
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
NationalServiceAndFederalReserveSystem-AdpIT786	**0.892**
SecuritySystemCompaniesV.3-AdpIT5981	**0.946**
SmartLibraryWebsite-AdpIT7861	0.762
SmsSystemV1.0-AdpLT7823	**0.91**
TrafficLicencingSysV4.0-AdpTR7531	0.892
VisitorReceptionSystem-AdpIT431	0.773

In the following table top three scoring projects are highlighted when Environment Sustainability has been considered as the main optimisation factor.

Top three projects by considering Environment Sustainability as the main optimisation factor

Alternatives / Projects	SCORE
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
NationalServiceAndFederalReserveSystem-AdpIT786	**0.892**
SecuritySystemCompaniesV.3-AdpIT5981	**0.91**
SmartLibraryWebsite-AdpIT7861	0.766
SmsSystemV1.0-AdpLT7823	**0.91**
TrafficLicencingSysV4.0-AdpTR7531	0.892
VisitorReceptionSystem-AdpIT431	0.8

To perform a practical application of the policy all projects data are gathered (the outcomes of these have been already presented above). This data is then used to calculate the *Median* and *Mode* of rankings for individual project in all scenarios. All this has been implemented in a spreadsheet tool (presented below) to perform complete calculations. This portfolio policy 8 spreadsheet is then further equipped with priority definition to automatically calculate the impact of priority on rankings (discussed later in this section). In the following table first all the projects are sorted alphabetically and then their rankings and scores are stored.

Alternatives / Projects	Economic		Social		Environment	
	Rank	Score	Rank	Score	Rank	Score
KioskAutomatesVehicleLicensing-AdpLT2319	5	0.87	5	0.87	5	0.87
NationalServiceAndFederalReserveSystem-AdpIT786	3	**0.89**	3	**0.89**	3	**0.89**
SecuritySystemCompaniesV.3-AdpIT5981	1	**0.95**	1	**0.95**	2	**0.91**
SmartLibraryWebsite-AdpIT7861	7	0.75	7	0.76	7	0.77
SmsSystemV1.0-AdpLT7823	2	**0.91**	2	**0.91**	1	**0.91**
TrafficLicencingSysV4.0-AdpTR7531	4	0.89	4	0.89	4	0.89
VisitorReceptionSystem-AdpIT431	6	0.76	6	0.77	6	0.80

The next step was to calculate the total rank and total score after merging policies' outcomes 5, 6, and 7. In the following table total rank and scores are presented.

Alternatives / Projects	Economic		Social		Environment		Total Rank	**Total Score**
	Rank	Score	Rank	Score	Rank	Score		
KioskAutomatesVehicleLicensing-AdpLT2319	5	0.87	5	0.87	5	0.87	15	**2.62**
NationalServiceAndFederalReserveSystem-AdpIT786	3	**0.89**	3	**0.89**	3	**0.89**	9	**2.68**
SecuritySystemCompaniesV.3-AdpIT5981	1	**0.95**	1	**0.95**	2	**0.91**	4	**2.80**
SmartLibraryWebsite-AdpIT7861	7	0.75	7	0.76	7	0.77	21	**2.27**
SmsSystemV1.0-AdpLT7823	2	**0.91**	2	**0.91**	1	**0.91**	5	**2.73**
TrafficLicencingSysV4.0-AdpTR7531	4	0.89	4	0.89	4	0.89	12	**2.68**
VisitorReceptionSystem-AdpIT431	6	0.76	6	0.77	6	0.80	18	**2.33**

The following outcomes show the resultant *Rank Median* of all the portfolio projects in all considered scenarios. Here Rank 1 means the highest priority and Rank 7 means the lowest priority. As shown in the following table, the project SecuritySystemCompaniesV.3-AdpIT5981 got the *ranked Median* value 1, followed by the SmsSystemV1.0-AdpLT7823 project that got ranked *Median value 2* and the third highest project is NationalServiceAndFederalReserveSystem-AdpIT786 with a *ranked Median value* 3. For case study organisation, three top projects are selected; however, other organisations are free to choose any number of top projects in each portfolio evaluation exercise.

	Economic	Social	Environment	Total Rank	**Total Score**	**Rank *Median***

Alternatives / Projects	Rank	Score	Rank	Score	Rank	Score				
KioskAutomatesVehicleLicensing-AdpLT2319	5	0.87	5	0.87	5	0.87	15	**2.62**	**5**	
NationalServiceAndFederalReserveSystem-AdpIT786	3	**0.89**	3	**0.89**	3	**0.89**	9	**2.68**	**3**	**3rd**
SecuritySystemCompaniesV.3-AdpIT5981	1	**0.95**	1	**0.95**	2	**0.91**	4	**2.80**	**1**	**1st**
SmartLibraryWebsite-AdpIT7861	7	0.75	7	0.76	7	0.77	21	**2.27**	**7**	
SmsSystemV1.0-AdpLT7823	2	**0.91**	2	**0.91**	1	**0.91**	5	**2.73**	**2**	**2nd**
TrafficLicencingSysV4.0-AdpTR7531	4	0.89	4	0.89	4	0.89	12	**2.68**	**4**	
VisitorReceptionSystem-AdpIT431	6	0.76	6	0.77	6	0.80	18	**2.33**	**6**	

The following outcomes show the resultant *Rank Mode* of all the portfolio projects in all considered scenarios. Here again Rank 1 means the highest priority and Rank 10 means the lowest priority. As presented in the following table the project SecuritySystemCompaniesV.3-AdpIT5981 got the *ranked Mode* value 1, followed by the SmsSystemV1.0-AdpLT7823 project that got *ranked Mode* value 2 and the third highest project is NationalService-AndFederalReserveSystem-AdpIT786 with a *ranked Mode* value 3. As this can be seen from the data, in both *Median* and *Mode* calculation same projects were appeared on the top and in a same order. One benefit of, which could be argued here, of using *Mode* over *Median*, is that *Mode* gives discrete values so decision-making could be more straightforward. However, a problem with *Mode* calculation has been found i.e. *Not Applicable* when all projects have distinct values. According to the definition of *Mode*, the "*Mode*" is the value that occurs most often. If no number is repeated, then there is no *Mode* for the list. Therefore, it can be concluded with this outcome that *Mode* is not always useful to prioritise projects in a portfolio.

Alternatives / Projects	Economic		Social		Environment		Rank *Mode*	
	Rank	Score	Rank	Score	Rank	Score		
KioskAutomatesVehicleLicensing-AdpLT2319	5	0.87	5	0.87	5	0.87	**5**	
NationalServiceAndFederalReserveSystem-AdpIT786	3	**0.89**	3	**0.89**	3	**0.89**	**3**	**3rd**
SecuritySystemCompaniesV.3-AdpIT5981	1	**0.95**	1	**0.95**	2	**0.91**	**1**	**1st**
SmartLibraryWebsite-AdpIT7861	7	0.75	7	0.76	7	0.77	**7**	
SmsSystemV1.0-AdpLT7823	2	**0.91**	2	**0.91**	1	**0.91**	**2**	**2nd**
TrafficLicencingSysV4.0-AdpTR7531	4	0.89	4	0.89	4	0.89	**4**	
VisitorReceptionSystem-AdpIT431	6	0.76	6	0.77	6	0.80	**6**	

By looking at the *Mean* calculation for both project rankings and project scores. The following datasets show the outcomes in terms of *Mean of Rank* and *Mean of Scores.* Here once again the top three projects are SecuritySystemCompaniesV.3-AdpIT5981, SmsSystemV1.0-AdpLT7823 and NationalServiceAndFederalReserve-System-AdpIT786, respectively. When comparing all the project outcomes with *Rank Median*, it has been observed that both *Rank Mean* and *Rank Median* provided same results, which also matched to the outcomes produced by taking the *Mean* of scores.

However, a problem was found in the *Mean of Scores*, that both the NationalServiceAnd-FederalReserveSystem-AdpIT786 project and the trafficLicencingSysV4.0-AdpTR7531 project scored the same 0.268 score. This outcome is not harmonizing with any of the above calculations; and thus, calculating *Mean* of score not a reliable outcome on its own.

Alternatives / Projects	Economic		Social		Environment		Rank *Mean*	***Mean* of Score**	
	Rank	Score	Rank	Score	Rank	Score			
KioskAutomatesVehicleLicensing-AdpLT2319	5	0.87	5	0.87	5	0.87	1.5	**0.262**	
NationalServiceAndFederalReserveSystem-AdpIT786	3	**0.89**	3	**0.89**	3	**0.89**	0.9	**0.268**	**3rd**
SecuritySystemCompaniesV.3-AdpIT5981	1	**0.95**	1	**0.95**	2	**0.91**	0.4	**0.280**	**1st**
SmartLibraryWebsite-AdpIT7861	7	0.75	7	0.76	7	0.77	2.1	**0.227**	
SmsSystemV1.0-AdpLT7823	2	**0.91**	2	**0.91**	1	**0.91**	0.5	**0.273**	**2nd**
TrafficLicencingSysV4.0-AdpTR7531	4	0.89	4	0.89	4	0.89	1.2	**0.268**	**3rd**
VisitorReceptionSystem-AdpIT431	6	0.76	6	0.77	6	0.80	1.8	**0.233**	

In conclusion, the above part of policy 8 allowed the calculation of *Mean*, *Median* and *Mode* of rankings as well as *Mean* of projects scores for individual project in three sustainability related scenarios. This gives flexibility to the decision makers to base their portfolio selection decision on either of the calculation method. However, above practical implementation has reviled that calculating *Mean* and *Median* is more appropriate as compared to the *Mode*.

In the second part of this portfolio policy 8, the above spreadsheet is further equipped with *priority* definitions to automatically calculate the impact of priority on rankings and scores. This allowed incorporation of further priorities to individual sustainability related scenarios. So, in addition to the calculation of *Mean*, *Median* and *Mode* of individual projects rankings and scores in all scenarios, the policy 8 allows prioritising the rankings and scores. The following spreadsheet snapshot is showing this practical application of this to establish further discussion on "*if defining scenarios priorities on resultant ranks can help in the decision*". As shown in the spreadsheet snapshot, first all the projects are sorted alphabetically and then their rankings are stored. Moreover, the top header is showing the mechanism of defining priority. The default priority is set to 1. There is no limit on defining a priority and any number can be specified. The spreadsheet tool automatically performs rest of the calculations.

Snapshot of the Spreadsheet – Default Priority

Alternatives / Projects	Priority 1 Economic			Priority 1 Social			Priority 1 Environment			Total Rank	Total Score	Rank *Median*	Prioritised Rank *Median*	Rank *Mode*	Prioritised Rank *Mode*	Rank *Mean*	Prioritised Rank *Mean*	*Mean* of Score
	Rank	Priority Rank	Score	Rank	Priority Rank	Score	Rank	Priority Rank	Score									
KioskAutomatesVehicleLicensing-AdpLT2319	5	5	0.87	5	5	0.87	5	5.00	0.87	15	2.62	5	5.00	5	15.00	1.5	1.50	0.262
NationalServiceAndFederalReserveSystem-AdpIT786	3	3	0.89	3	3	0.89	3	3.00	0.89	9	2.68	3	3.00	3	9.00	0.9	0.90	0.268
SecuritySystemCompaniesV.3-AdpIT5981	1	1	0.95	1	1	0.95	2	2.00	0.91	4	2.80	1	1.00	1	4.00	0.4	0.40	0.280
SmartLibraryWebsite-AdpIT7861	7	7	0.75	7	7	0.76	7	7.00	0.77	21	2.27	7	7.00	7	21.00	2.1	2.10	0.227
SmsSystemV1.0-AdpLT7823	2	2	0.91	2	2	0.91	1	1.00	0.91	5	2.73	2	2.00	2	5.00	0.5	0.50	0.273
TrafficLicencingSysV4.0-AdpTR7531	4	4	0.89	4	4	0.89	4	4.00	0.89	12	2.68	4	4.00	4	12.00	1.2	1.20	0.268
VisitorReceptionSystem-AdpIT431	6	6	0.76	6	6	0.77	6	6.00	0.80	18	2.33	6	6.00	6	18.00	1.8	1.80	0.233

Snapshot of Spreadsheet – Priority Definition

	Priority	1			Priority	5			Priority	1				
		Economic				Social				Environment				
	Rank	Priority Rank	Score		Rank	Priority Rank	Score		Rank	Priority Rank	Score		Total Rank	**Total Score**
KioskAutomatesVehicleLicensing-AdpLT2319	5	5.00	0.87		5	1.00	0.87		5	5.00	0.87		15	**2.6**
NationalServiceAndFederalReserveSystem-AdpIT786	3	3.00	0.89		3	0.60	0.89		3	3.00	0.89		9	**2.7**
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	0.95		1	0.20	0.95		2	2.00	0.91		4	**2.8**
SmartLibraryWebsite-AdpIT7861	7	7.00	0.75		7	1.40	0.76		7	7.00	0.77		21	**2.3**
SmsSystemV1.0-AdpLT7823	2	2.00	0.91		2	0.40	0.91		1	1.00	0.91		5	**2.7**
TrafficLicencingSysV4.0-AdpTR7531	4	4.00	0.89		4	0.80	0.89		4	4.00	0.89		12	**2.7**
VisitorReceptionSystem-AdpIT431	6	6.00	0.76		6	1.20	0.77		6	6.00	0.80		18	**2.3**

The following calculations show the effect on defining priority 5 to scenario 6 (Social). It has been found that in the original calculations without priority, the project SecuritySystemCompaniesV.3-AdpIT5981 got the ranked *Median* value 1, followed by the SmsSystemV1.0-AdpLT7823 project that got ranked *Median* value 2 and the third highest project is NationalServiceAndFederalReserveSystem-AdpIT786 with a ranked *Median* value 3. However, after defining priority both SecuritySystemCompaniesV.3-AdpIT5981 and the SmsSystemV1.0-AdpLT7823 projects are now ranking equally. However, it has been observed again that defining priority and calculating *Median* may not be a correctly workable solution. This is especially true in the cases of changing priority of only one scenario and if the project was already scoring *low* or *high*. In such a case, the change won't be reflected in the *Median* calculation and the middle scoring project would still appear as favourite in the resultant portfolio.

	Priority	1		Priority	5		Priority	1					
	Economic			Social			Environment			Total Rank	Total Score	Rank *Median*	Prioritised Rank *Median*
	Rank	Priority Rank	Score	Rank	Priority Rank	Score	Rank	Priority Rank	Score				
KioskAutomatesVehicleLicensing-AdpLT2319	5	5.00	0.87	5	1.00	0.87	5	5.00	0.87	15	**2.6**	**5**	**5.00**
NationalServiceAndFederalReserveSystem-AdpIT786	3	3.00	0.89	3	0.60	0.89	3	3.00	0.89	9	**2.7**	**3**	**3.00**
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	0.95	1	0.20	0.95	2	2.00	0.91	4	**2.8**	**1**	**1.00**
SmartLibraryWebsite-AdpIT7861	7	7.00	0.75	7	1.40	0.76	7	7.00	0.77	21	**2.3**	**7**	**7.00**
SmsSystemV1.0-AdpLT7823	2	2.00	0.91	2	0.40	0.91	1	1.00	0.91	5	**2.7**	**2**	**1.00**
TrafficLicencingSysV4.0-AdpTR7531	4	4.00	0.89	4	0.80	0.89	4	4.00	0.89	12	**2.7**	**4**	**4.00**
VisitorReceptionSystem-AdpIT431	6	6.00	0.76	6	1.20	0.77	6	6.00	0.80	18	**2.3**	**6**	**6.00**

The following calculations show the effect on *Mode* by defining priority 5 to scenario 6 (Social). It has been found that in the original calculations without priority, the project SecuritySystemCompaniesV.3-AdpIT5981 got the ranked value 1 with a clear margin from SmsSystemV1.0-AdpLT7823 project that got ranked second 2. However, after defining priority both SecuritySystemCompaniesV.3-AdpIT5981 and the SmsSystemV1.0-AdpLT7823 projects ranking data becomes inapplicable. This is because now all their values are different.

	Priority	1		Priority	5		Priority	1		Rank *Mode*	Prioritised Rank *Mode*
	Economic			Social			Environment				
	Rank	Priority Rank	Score	Rank	Priority Rank	Score	Rank	Priority Rank	Score		
KioskAutomatesVehicleLicensing-AdpLT2319	5	5.00	0.87	5	1.00	0.87	5	5.00	0.87	**5**	5.00
NationalServiceAndFederalReserveSystem-AdpIT786	3	3.00	0.89	3	0.60	0.89	3	3.00	0.89	**3**	3.00
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	0.95	1	0.20	0.95	2	2.00	0.91	**1**	#N/A
SmartLibraryWebsite-AdpIT7861	7	7.00	0.75	7	1.40	0.76	7	7.00	0.77	**7**	7.00
SmsSystemV1.0-AdpLT7823	2	2.00	0.91	2	0.40	0.91	1	1.00	0.91	**2**	#N/A
TrafficLicencingSysV4.0-AdpTR7531	4	4.00	0.89	4	0.80	0.89	4	4.00	0.89	**4**	4.00
VisitorReceptionSystem-AdpIT431	6	6.00	0.76	6	1.20	0.77	6	6.00	0.80	**6**	6.00

It is the case with prioritised *Mean* calculation, the following calculations show the effect on *Mean* by defining priority 5 to scenario 6 (Social). It has been found that in the original calculations without priority, the project SecuritySystem-CompaniesV.3-AdpIT5981 got the ranked *Mean* value 1.33 with a clear edge from SmsSystemV1.0-AdpLT7823 project that got ranked second 1.67. However, after defining priority both SecuritySystemCompaniesV.3-AdpIT5981 and the SmsSystemV1.0-AdpLT7823 project ranked closely with rounded value i.e. 1.1 (i.e. 1.07 and 1.13). Therefore, the portfolio managers; based on the prioritised *Mean* ranks may see both SecuritySystemCompaniesV.3-AdpIT5981 and SmsSystemV1.0-AdpLT823 projects as equally important.

	Priority 1			Priority 5			Priority 1				
	Economic			Social			Environment				
	Rank	Priority Rank	Score	Rank	Priority Rank	Score	Rank	Priority Rank	Score	Rank *Mean*	Prioritised Rank *Mean*
KioskAutomatesVehicleLicensing-AdpLT2319	5	5.00	0.87	5	1.00	0.87	5	5.00	0.87	5.00	3.67
NationalServiceAndFederalReserveSystem-AdpIT786	3	3.00	0.89	3	0.60	0.89	3	3.00	0.89	3.00	2.20
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	0.95	1	0.20	0.95	2	2.00	0.91	1.33	1.07
SmartLibraryWebsite-AdpIT7861	7	7.00	0.75	7	1.40	0.76	7	7.00	0.77	7.00	5.13
SmsSystemV1.0-AdpLT7823	2	2.00	0.91	2	0.40	0.91	1	1.00	0.91	1.67	1.13
TrafficLicencingSysV4.0-AdpTR7531	4	4.00	0.89	4	0.80	0.89	4	4.00	0.89	4.00	2.93
VisitorReceptionSystem-AdpIT431	6	6.00	0.76	6	1.20	0.77	6	6.00	0.80	6.00	4.40

In conclusion, as it has been already established above that calculating *Mode* for project ranking is not a reliable solution. This is due to the *not-applicability* problems with *Mode* it is recommended that portfolio managers should stick to *Mean* calculations for straightforward results while applying policies such as this Policy 8.

The following datasets show the complete picture of *Median*, *Mode*l and *Mean* calculations of the cases discussed above.

Prioritise Rank	Priority 1			Priority 5			Priority 1			Outcome		*Median*		*Mode*		*Mean*		
	Economic			Social			Environment											
Alternatives	Rank	Priority Rank	**Score**	Rank	Priority Rank	**Score**	Rank	Priority Rank	**Score**	**Total Rank**	**Total Score**	**Rank *Median***	**Prioritised Rank *Median***	**Rank *Mode***	**Prioritised Rank *Mode***	***Mean* of Rank**	***Mean* of Prioritised Rank**	***Mean* of Score**
KioskAutomatesVehicleLicensing-AdpLT2319	5	5.00	0.87	5	1.00	0.87	5	5.00	0.87	15	**2.6**	**5**	**5.00**	**5**	5.00	5.00	3.67	0.87
NationalServiceAndFederalReserveSystem-AdpIT786	3	3.00	0.89	3	0.60	0.89	3	3.00	0.89	9	**2.7**	**3**	**3.00**	**3**	3.00	3.00	2.20	0.89
SecuritySystemCompaniesV.3-AdpIT5981	1	1.00	0.95	1	0.20	0.95	2	2.00	0.91	4	**2.8**	**1**	**1.00**	**1**	#N/A	1.33	1.07	0.93
SmartLibraryWebsite-AdpIT7861	7	7.00	0.75	7	1.40	0.76	7	7.00	0.77	21	**2.3**	**7**	**7.00**	**7**	7.00	7.00	5.13	0.76
SmsSystemV1.0-AdpLT7823	2	2.00	0.91	2	0.40	0.91	1	1.00	0.91	5	**2.7**	**2**	**1.00**	**2**	#N/A	1.67	1.13	0.91
TrafficLicencingSysV4.0-AdpTR7531	4	4.00	0.89	4	0.80	0.89	4	4.00	0.89	12	**2.7**	**4**	**4.00**	**4**	4.00	4.00	2.93	0.89
VisitorReceptionSystem-AdpIT431	6	6.00	0.76	6	1.20	0.77	6	6.00	0.80	18	**2.3**	**6**	**6.00**	**6**	6.00	6.00	4.40	0.78

Likewise the observation in policy 4, after analysing the above data it is again evident that defining priority to *ranks* is not an ideal solution. This is mainly because it is not considering the actual scores of projects or the extent of gap in the favourability of each project; and thus, cannot tell how closely two or more projects are in a portfolio after priority definitions. Therefore, priorities to project scores are also implemented and then calculated their *Mean*, *Median* and *Mode* of for individual project in all scenarios, which are discussed as follows. The top header is displaying the mechanism of defining priority on scores. The default priority is set to 1. There is no limit on defining a priority and any number can be specified. The following calculations show the effect on defining priorities.

Prioritise Score		1		2		2
	Economic		Social		Environment	
Alternatives	Score	Priority Score	Score	Priority Score	Score	Priority Score
KioskAutomatesVehicleLicensing-AdpLT2319	0.87	0.87	0.87	1.75	0.87	1.75
NationalServiceAndFederalReserveSystem-AdpIT786	0.89	0.89	0.89	1.78	0.89	1.78
SecuritySystemCompaniesV.3-AdpIT5981	0.95	0.95	0.95	1.89	0.91	1.82
SmartLibraryWebsite-AdpIT7861	0.75	0.75	0.76	1.52	0.77	1.53
SmsSystemV1.0-AdpLT7823	0.91	0.91	0.91	1.82	0.91	1.82
TrafficLicencingSysV4.0-AdpTR7531	0.89	0.89	0.89	1.78	0.89	1.78
VisitorReceptionSystem-AdpIT431	0.76	0.76	0.77	1.55	0.80	1.60

The following calculations show the effect on *Median* by defining priorities. It has been observed that defining priority and calculating *Median* may not a workable solution. This is especially true in the cases of changing priority of only one scenario and if the project was already scoring *low* or *high*. In such a case, the change won't be reflected in the *Median* calculation and the middle scoring project would still appear as favourite in the resultant portfolio.

Prioritise Score		1		2		2				
	Economic		Social		Environment			*Median*		
Alternatives	Score	Priority Score	Score	Priority Score	Score	Priority Score		Rank *Median*	Prioritised Score *Median*	
KioskAutomatesVehicleLicensing-AdpLT2319	0.87	0.87	0.87	1.75	0.87	1.75		**0.87**	**1.75**	
NationalServiceAndFederalReserveSystem-AdpIT786	0.89	0.89	0.89	1.78	0.89	1.78	**3rd**	**0.89**	**1.78**	2nd
SecuritySystemCompaniesV.3-AdpIT5981	0.95	0.95	0.95	1.89	0.91	1.82	**1st**	**0.95**	**1.82**	1st
SmartLibraryWebsite-AdpIT7861	0.75	0.75	0.76	1.52	0.77	1.53		**0.76**	**1.52**	
SmsSystemV1.0-AdpLT7823	0.91	0.91	0.91	1.82	0.91	1.82	**2nd**	**0.91**	**1.82**	1st
TrafficLicencingSysV4.0-AdpTR7531	0.89	0.89	0.89	1.78	0.89	1.78	**3rd**	**0.89**	**1.78**	2nd
VisitorReceptionSystem-AdpIT431	0.76	0.76	0.77	1.55	0.80	1.60		**0.77**	**1.55**	

The following calculations show the *Mode* of Score calculation and the effect on *Mode* after priority definition. As it can be seen that it is *not possible* to calculate *Mode* of score values. This is because mostly the projects scores consist of distinct values and they remain distinct even after applying priority.

Prioritise Score		1		2		2		Mode	
		Economic		Social		Environment			
Alternatives	Score	Priority Score	Score	Priority Score	Score	Priority Score	Rank *Mode*	Prioritised Score *Mode*
KioskAutomatesVehicleLicensing-AdpLT2319	0.87	0.87	0.87	1.75	0.87	1.75	**0.874**	1.75
NationalServiceAndFederalReserveSystem-AdpIT786	0.89	0.89	0.89	1.78	0.89	1.78	**0.892**	1.78
SecuritySystemCompaniesV.3-AdpIT5981	0.95	0.95	0.95	1.89	0.91	1.82	**0.946**	#N/A
SmartLibraryWebsite-AdpIT7861	0.75	0.75	0.76	1.52	0.77	1.53	**#N/A**	#N/A
SmsSystemV1.0-AdpLT7823	0.91	0.91	0.91	1.82	0.91	1.82	**0.91**	1.82
TrafficLicencingSysV4.0-AdpTR7531	0.89	0.89	0.89	1.78	0.89	1.78	**0.892**	1.78
VisitorReceptionSystem-AdpIT431	0.76	0.76	0.77	1.55	0.80	1.60	**#N/A**	#N/A

The following data shows the calculation of prioritised score *Mean*. Although, in this dataset there is no change in the top projects, but already established in the Scenario 4 of phase 2 that defining priority can change the ordering of projects in a portfolio. The following datasets show the complete picture of *Median*, *Mode* and *Mean* calculations of the cases discussed above.

Prioritise Score		1		2		2		Mean		
		Economic		Social		Environment				
Alternatives	Score	Priority Score	Score	Priority Score	Score	Priority Score	*Mean* of Score	Prioritised Score *Mean*	
KioskAutomatesVehicleLicensing-AdpLT2319	0.87	0.87	0.87	1.75	0.87	1.75	**0.87**	1.46	
NationalServiceAndFederalReserveSystem-AdpIT786	0.89	0.89	0.89	1.78	0.89	1.78	**0.89**	1.49	**3rd**
SecuritySystemCompaniesV.3-AdpIT5981	0.95	0.95	0.95	1.89	0.91	1.82	**0.93**	1.55	**1st**
SmartLibraryWebsite-AdpIT7861	0.75	0.75	0.76	1.52	0.77	1.53	**0.76**	1.27	
SmsSystemV1.0-AdpLT7823	0.91	0.91	0.91	1.82	0.91	1.82	**0.91**	1.52	**2nd**
TrafficLicencingSysV4.0-AdpTR7531	0.89	0.89	0.89	1.78	0.89	1.78	**0.89**	1.49	**3rd**
VisitorReceptionSystem-AdpIT431	0.76	0.76	0.77	1.55	0.80	1.60	**0.78**	1.30	

In conclusion, above scenarios implementations showed that calculating *Mean* is more appropriate as compared to the *Median* and *Mode*. This is especially because changing priority of only one scenario and if the project was already scoring low or high will not be reflected in the *Median* calculation and the middle-scoring project would still appear as favourite in the resultant portfolio. Moreover, for distinct ranked values of projects, *Mode* cannot be calculated. Overall, the policy 8 gave added control to the portfolio decision-makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean*. This is especially convenient when the portfolio decision makers perceive one or more scenarios as an organisational priority.

5.4 Evaluation Findings and Discussion Phase 2

As discussed above, once all the projects data in a portfolio have been evaluated, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects using several portfolio-balancing policies. These portfolio-balancing policies helped portfolio managers in achieving a portfolio that met both the strategic and sustainability objectives of the organisation optimally. To further evaluate the outcomes of this research, a phase 2 of the implementation was carried out. In this phase, a set of seven alternatives / projects were considered for evaluation / portfolio balancing by excluding the top three scoring projects in the phase 1 and adding three new projects. In this regard, all relevant evaluation information of the projects and their data collection is presented in Appendices. The evaluation criteria's priorities remain the same as in phase 1, which were obtained based on the different levels of portfolio balancing needs of the case study organisation. Therefore, in this phase same 13 scenarios of evaluation criteria's priorities specifications were utilised and apply them on seven phase 2 alternatives / projects. The details of pairwise comparisons in these 13 scenarios have been already specified in the initial sections of this chapter. In this section, the details on findings on portfolio policies when applied to seven alternatives / projects (i.e. phase 2) are discussed. The following are the alternatives / projects that are evaluated in this phase 2:

SPPS-IT Implementation and Evaluation – Phase 2	
Project 1	ConditionNotebookV2-AdpLT9765
Project 2	KioskAutomatesVehicleLicensing-AdpLT2319
Project 3	ManagementSystem-AdpIT963
Project 4	SmartLibraryWebsite-AdpIT7861
Project 5	StatisticsPortsSecuritySystem-AdpLT7801
Project 6	TrafficLicencingSysV4.0-AdpTR7531
Project 7	VisitorReceptionSystem-AdpIT431

5.4.1 Policy 1

The policy one stated: "define the portfolio evaluation criteria priorities based on the portfolio balancing requirement in ten scenarios". This enabled the feeding of all 7 phase 2 projects portfolio data into the system for AHP evaluation. Because of the application of Part 1 of the Policy 1, projects portfolio evaluation criteria in 10 different levels of priorities was achieved, which is same as presented in phase 1 above and only summarised in this section. The second part of the Policy 1 stated: *"for all the scenarios, obtain and process all projects (alternatives) portfolio data as per the defined portfolio evaluation criteria",* which was performed. The outcomes enabled the feeding of all the phase 2 projects (alternatives) portfolio data into the system for AHP evaluation; (2) for all the *scenarios* in phase 2; all projects data as per the defined portfolio evaluation criteria were obtained and processed. The following sections present the findings on portfolio balancing policies including more comparative discussion across all *scenarios*.

5.4.2 Policy 2

Calculation and outcomes of this policy 2 in phase 2

Projects (Alternatives)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
ConditionNotebookV2-AdpLT9765	0.84	0.853	0.000	0.000	0.851	0.000	0.000	0.000	0.000	0.000	2.544
KioskAutomatesVehicleLicensing-AdpLT2319	0.000	0.000	0.000	0.923	0.000	0.838	0.853	0.923	0.873	0.855	**5.265**
ManagementSystem-AdpIT963	0.000	0.000	0.839	0.000	0.000	0.000	0.786	0.000	0.000	0.000	1.625
SmartLibraryWebsite-AdpIT7861	0.899	0.896	0.000	0.000	0.913	0.828	0.000	0.000	0.000	0.000	3.536
StatisticsPortsSecuritySystem-AdpLT7801	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
TrafficLicencingSysV4.0-AdpTR7531	0.000	0.000	0.876	0.906	0.000	0.000	0.929	0.94	0.955	0.875	**5.481**
VisitorReceptionSystem-AdpIT431	0.894	0.888	0.834	0.725	0.887	0.84	0.000	0.708	0.749	0.807	**7.332**

The major finding of this policy implementation in phase 2 is getting well-defined outcomes in terms of overall high scoring projects. The outcomes suggested that VisitorReceptionSystem-AdpIT431 is the most favourable project. The second most favourable project is TrafficLicencingSysV4.0-AdpTR7531 which scored highest followed by the KioskAutomatesVehicleLicensing-AdpLT2319 which clear margins from rest of the projects. Moreover, the StatisticsPortsSecuritySystem-AdpLT7801 project appeared as the least favourable project as it never came in top three in any of the scenarios. The results would have been slightly different if top 5 projects were selected as StatisticsPortsSecuritySystem-AdpLT7801 project did appeared on 5th position in the scenarios 3 and 7. The justification of selecting top 3 projects by the case study organisation has been already given above; however, other organisations should be determining the top number of projects as per their funding and other constraints. In conclusion, this policy is not only giving an overall tool to select any number of top scoring projects in all scenarios, but it is also giving a list of those projects which are least favourable.

5.4.3 Policy 3

This policy gives flexibility to the decision makers to base their portfolio selection decision either of the *Mean, Median* or *Mode* of the ranking for individual projects in all scenarios. It reads "*calculate the Median and Mode of rankings for individual projects and the Mean of project scores in all scenarios*".

Findings show that same projects got selected for both *Median* and *Mode* calculations. However, in the practical investigation calculating *Median* is more appropriate as compared to the *Mode*. This is because for distinct ranked values of all the projects, *Mode* cannot be calculated. Moreover, the *Mean* of individual project scores is calculated in all scenarios to provide a conflict resolution mechanism when two projects score the similar *Median* or *Mode* value. So overall, this policy provides individual as well as combined mechanisms for project selection, where the *Mean* of projects scores can be considered for further analysis and decision-making.

The following datasets demonstrate the outcomes in terms of Total Rank, Total Score, *Mean* of Rank and *Mean* of Scores. Here once again the top three projects are the same. Although, apparently the StatisticsPortsSecuritySystem-AdpLT7801 project and the ConditionNotebookV2-AdpLT9765 project have similar *Mean* of Scores i.e. 0.72, the Total Score and *Mean* of Rank confirms that ConditionNotebookV2-AdpLT9765 is favourable than the StatisticsPorts-SecuritySystem-AdpLT7801 project. Same was the outcome in policy 2, where StatisticsPortsSecuritySystem-AdpLT7801 project was least favourable in the phase 2.

	Outcome		***Mean***	
Alternatives / Projects	**Total Rank**	**Total Score**	***Mean* of Rank**	***Mean* of Score**
ConditionNotebookV2-AdpLT9765	57	7.19	5.7	0.72
KioskAutomatesVehicleLicensing-AdpLT2319	**28**	**8.55**	**2.8**	**0.85**
ManagementSystem-AdpIT963	46	7.63	4.6	0.76
SmartLibraryWebsite-AdpIT7861	34	7.97	3.4	0.80
StatisticsPortsSecuritySystem-AdpLT7801	60	7.24	6	0.72
TrafficLicencingSysV4.0-AdpTR7531	**29**	**8.70**	**2.9**	**0.87**
VisitorReceptionSystem-AdpIT431	**26**	**8.11**	**2.6**	**0.81**

In conclusion, the Policy 3 allowed the calculation of *Mean, Median* and *Mode* of rankings as well as *Mean* of projects scores for individual project in all scenarios. Using this policy decision makers can base their portfolio selection decision on either of the calculation method.

5.4.4 Policy 4

The Policy 4 allowed incorporation of further priorities to the scores of individual scenarios with respect to the Policy 3. Consequently, in addition to the calculation of *Mean, Median* and *Mode* of individual project scores in all scenarios, the policy 4 allows prioritising the scores of each scenario. For example, if a project's score was 0.63 initially in scenario one, it could be priorities to 3.15 if its propriety is defined as 5 i.e. 0.63 * 5 = 3.15. This policy gave further flexibility to the decision makers to

base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean*, *Median* or *Mode* of individual project scores. This is especially valued when the portfolio decision makers perceive one or more scenarios as an organisational priority.

The spreadsheet data collected and calculated in the previous policy is further equipped with priority definition to automatically calculate the impact of priority on scores. As shown in the following table, first all the projects are sorted alphabetically and then their rankings are stored. Moreover, the top header is showing the mechanism of defining priority. The default priority is set to 1. There is no limit on defining a priority and any number can be specified. The spreadsheet tool automatically performs rest of the calculations.

This has been already established in policy 3 that calculating *Mode* for project rankings is not a reliable solution and organisations should only stick to *Median* and *Mean* for such calculations. Here, another finding was made that when priority is defined then calculating both *Median* and *Mode* for project scores is not a workable solution and organisations should only stick to *Mean* when applying priority. The following datasets show the complete picture of *Median*, *Mode* and *Mean* calculations of the cases discussed above.

	Median			*Mode*			*Mean*		
Alternatives / Projects	**Score *Median***	**Prioritised Score *Median***		**Score *Mode***	**Prioritised Score *Mode***		**Score *Mean***	**Prioritised Score *Mean***	
ConditionNotebookV2-AdpLT9765	0.74	0.74		#N/A	#N/A		0.72	1.22	
KioskAutomatesVehicleLicensing-AdpLT2319	**0.85**	**0.85**	2nd	0.923	0.923		**0.85**	**1.35**	2nd
ManagementSystem-AdpIT963	0.79	0.79		#N/A	#N/A		0.76	1.26	
SmartLibraryWebsite-AdpIT7861	0.79	0.79		#N/A	#N/A		0.80	1.34	
StatisticsPortsSecuritySystem-AdpLT7801	0.74	0.74		#N/A	#N/A		0.72	1.21	
TrafficLicencingSysV4.0-AdpTR7531	**0.88**	**0.89**	1st	#N/A	#N/A		**0.87**	**1.34**	1st
VisitorReceptionSystem-AdpIT431	**0.82**	**0.82**	3rd	#N/A	#N/A		**0.81**	**1.35**	3rd

5.4.1 Policy 5

To provide sustainability related portfolio decision making, a rigorous sustainability analysis is needed especially for organisations having multi-dimensional attributes towards environment, social and economic sustainability. In this regard, the Policies 5, 6 and 7 were developed and implemented, as discussed above in phase 1 implementation. This was done to perform further sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of the sustainably factors that likely to impact, either positively or negatively. These scenarios are especially useful for organisations

having multi-dimensional attributes towards environment, social and economic sustainability. The policy 5 states: *"select the top projects by considering Economic sustainability as the main optimisation factor".* This policy permitted to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Consequently, when in a portfolio Economic sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in a portfolio of projects. In the phase 1 Policy 5's distribution of criteria into different levels of priority was presented and the following scores were obtained by applying the pair-wise comparison using AHP technique. Economic Sustainability received 31.8 value as compared to the Social and Environment Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

Phase 2 - Alternatives / Projects - S11	SCORE
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.761
SmartLibraryWebsite-AdpIT7861	0.745
ManagementSystem-AdpIT963	0.722
StatisticsPortsSecuritySystem-AdpLT7801	0.658
ConditionNotebookV2-AdpLT9765	0.624

The phase 2 implementations of policy 5 included 7 projects / alternatives and their projects data and results are presented in the above table. The TrafficLicencingSysV4.0-AdpTR7531 clearly scored the highest score of 0.892 where the KioskAutomatesVehicleLicensing-AdpLT2319 project is not far off scoring 0.874. However, the VisitorReceptionSystem-AdpIT431 at number 3rd is scoring 0.761, and having large margin from top the two projects. Similarly, the SmartLibraryWebsite-AdpIT7861 project scoring 0.745 and ManagementSystem-AdpIT963 project scoring 0.722, are not far off from VisitorReceptionSystem-AdpIT431. Consequently, this portfolio is giving two clear options i.e. either to select top 2 or top 5 projects. Comparatively, the last two projects scored very low and this policy has brought top projects supporting economic sustainability. Later in the implementation phase 2 - policy 8, a combined effect of all sustainability related factors through rankings is presented.

5.4.2 Policy 6

The policy 6 allowed to priorities those projects that have positive societal implications or their negative impacts on social stability are either avoided or mitigated during the life of the project. The policy 6 is defined as: *"select the top three projects by considering Social sustainability as the main optimisation factor".* The consideration of *Social* sustainability in project selection is to ensure that project maintains social stability. In addition, it is evaluated that the project considered issues related to the level and degree of acceptability of a project to the community, the local representatives, the executing agency etc. When in a portfolio *Social* sustainability is

selected as the main optimisation factor then it is given the highest priority against every other factor. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in this portfolio of projects. In the phase 1, Policy 6's distribution of criteria into different levels of priority is presented and the following scores were obtained by applying the pair-wise comparison using AHP technique. Social Sustainability received 31.8 value as compared to the Economic and Environment Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

Phase 2 - Alternatives / Projects - S12	SCORE
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.773
SmartLibraryWebsite-AdpIT7861	0.762
ManagementSystem-AdpIT963	0.745
ConditionNotebookV2-AdpLT9765	0.695
StatisticsPortsSecuritySystem-AdpLT7801	0.689

The phase 2 implementations of policy 6 included same 7 projects / alternatives (as of policy 6) and their projects data and results are presented in the above table. The outcome of this phase 2 - policy 6 is not dissimilar than the policy 5 where Economic Sustainability was given the highest priority. Practical application of this policy showed that although projects have scored slightly differently when Social and Economic Sustainability were interchangeably considered on higher priority, the top projects remained in a similar sequence. However, there is a difference in resultant sequence in the last two projects in the portfolio. In the above policy 5 the lowest ranked project was ConditionNotebookV2-AdpLT9765, whereas in policy 6 the StatisticsPortsSecuritySystem-AdpLT7801 appeared as least ranked. In terms of top ranked projects, this portfolio is giving two clear options i.e. either to select top two or five projects e.g. the top two projects include TrafficLicencingSysV4.0-AdpTR7531 that scored highest 0.892 and KioskAutomatesVehicleLicensing-AdpLT2319 that scored second highest 0.874 but remained close to the top scorer. Comparatively, the last two projects scored very low and the combined effect of all sustainability related factors are presented in phase 2 policy 8.

5.4.3 Policy 7

The policy 7 was developed to select projects based on the *Environmental* sustainability and it allowed to priorities projects that have positive *environmental* implications or their negative impacts on *environment* are either avoided or mitigated during the life of the project. It stated: *"select the top three projects by considering Environmental sustainability as the main optimisation factor".* When in a portfolio Environmental sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in a portfolio of projects. In the phase 1, Policy 7's distribution of criteria into different levels of priority is presented and the following scores were obtained by applying the pair-wise comparison using AHP technique. Environment Sustainability received 31.8 value as compared to the Economic and Social

Sustainability that are on 1.6. All the other criteria factors have the equal priority of 7.2.

Phase 2 - Alternatives / Projects - S13	SCORE
TrafficLicencingSysV4.0-AdpTR7531	0.892
KioskAutomatesVehicleLicensing-AdpLT2319	0.874
VisitorReceptionSystem-AdpIT431	0.8
SmartLibraryWebsite-AdpIT7861	0.766
StatisticsPortsSecuritySystem-AdpLT7801	**0.752**
ManagementSystem-AdpIT963	**0.735**
ConditionNotebookV2-AdpLT9765	**0.669**

Some of the outcomes of this policy 7; especially related to the middle order project ranking, are not like the policy 5 and 6 where Economic and Social Sustainability were given the highest priority. In the phase 2 - policy 7, the TrafficLicencingSysV4.0-AdpTR7531 scored the highest 0.892 score, followed by KioskAutomatesVehicleLicensing-AdpLT2319 scoring 0.874 and VisitorReception-System-AdpIT431 scoring at 0.8. The most interesting finding in this implementation is related to the StatisticsPortsSecuritySystem-AdpLT7801 project. Recalling the position of StatisticsPortsSecuritySystem-AdpLT7801 in policy 5 and 6, in policy 5 the StatisticsPortsSecuritySystem-AdpLT7801 came of second last position and in policy 6 StatisticsPortsSecuritySystem-AdpLT7801 project came on last position. Consequently, in both policies 5 and 6 the StatisticsPortsSecuritySystem-AdpLT7801 appeared as not selectable or least favourable projects. However, in this policy 7, the StatisticsPortsSecuritySystem-AdpLT7801 came on 5th position, which means that if top five projects are selected then the StatisticsPortsSecuritySystem-AdpLT7801 will also be selected. When looking at the data (as presented in Appendices) one of the main reason that StatisticsPortsSecuritySystem-AdpLT7801 has scored better is that ManagementSystem-AdpIT963 and ConditionNotebookV2-AdpLT9765 projects are comparatively less environment friendly. On the other side the ConditionNotebookV2-AdpLT9765 is more suitable in terms of Economic Sustainability as it is related to reuse / recycling of existing computing equipment. In conclusion, it was practically seen again (previously in phase 1) that the policies 5, 6 and 7 are providing the required means to portfolio managers to make inform decisions. Moreover, as detailed in phase 1 there is no direct relationship between various sustainability factors, it is observed that one factors sometime influence other; for example, in some projects the negative *Environmental* impacts may yield benefits at a reduced rate depending on the extent of environmental costs, such negative impacts may in fact contribute to the net losses to the economy. To further consider the combined effect of *Economic,* Social and *Environmental sustainability* on a portfolio of projects, the Policy 8 on phase 2 projects was implemented, which presented in the following section of this chapter.

5.4.4 Policy 8

The Policy 8 stats that "calculate the Median and Mode of individual project rankings and Mean of project score in three scenarios where in each of them Economic, Social and Environmental sustainability was considered as the main optimisation factor, respectively". The policy 8 allows us to observe a combined effect of Economic, Social and Environmental sustainability factors on a portfolio of projects. In this policy implementation, the three scenarios specified above are used. Once this is done, it further allowed incorporating further priority to any of the scenarios. As demonstrated in phase 1, this policy gave a worthy control to the decision makers to base their portfolio selection decision by first giving different priorities to Economic, Social and Environmental optimisation factor scenarios, and then by observing the calculated Median or Mode of individual project rankings.

As this can be seen from the data in following table, in both *Median* and *Mode* calculation same projects were appeared on the top and in a same order. One benefit of using *Mode* over *Median*, which has already been argued and established in Phase 1 implementation, *Mode* gives discrete values so decision-making could be more straightforward. However, a problem with *Mode* calculation was found that it sometimes becomes *unavailable*. Therefore, it is concluded that *Mode* is not always useful to prioritise projects in a portfolio and thus in the next table the *Mean* of scores is presented.

	Economic			Social			Environment		*Median*	*Mode*
Alternatives / Projects	Rank	**Score**	.	Rank	**Score**	.	Rank	**Score**	**Rank *Median***	**Rank *Mode***
ConditionNotebookV2-AdpLT9765	7	0.624		7	0.624		7	0.624	**7**	**7**
KioskAutomatesVehicleLicensing-AdpLT2319	2	0.874		2	0.874		2	0.874	**2**	**2**
ManagementSystem-AdpIT963	5	0.722		5	0.722		5	0.722	**5**	**5**
SmartLibraryWebsite-AdpIT7861	4	0.745		4	0.745		4	0.745	**4**	**4**
StatisticsPortsSecuritySystem-AdpLT7801	6	0.658		6	0.658		6	0.658	**6**	**6**
TrafficLicencingSysV4.0-AdpTR7531	1	0.892		1	0.892		1	0.892	**1**	**1**
VisitorReceptionSystem-AdpIT431	3	0.761		3	0.761		3	0.761	**3**	**3**

The following datasets show the outcomes in terms of *Mean of Rank* and *Mean of Scores.* Here once again the top three projects are TrafficLicencingSysV4.0-AdpTR7531, KioskAutomatesVehicleLicensing-AdpLT2319 and VisitorReceptionSystem-AdpIT431. When comparing all the project outcomes with *Rank Median*, it has been observed that both *Rank Mean* and *Rank Median* provided same projects results, which also matched to the outcomes produced by taking the

Mean of scores. It has been already established in phase 1 that sometime it may not be enough to only rely on *Mean* of scores especially if two or more projects score the same or close to each other. For example, in the following portfolio the TrafficLicencingSysV4.0-AdpTR7531 scored 0.27 and KioskAutomatesVehicleLicensing-AdpLT2319 scored 0.26 with the difference of 0.01 only. In such a case, organisations may also consider *Mean of Rank* to make an informed decision. In the following portfolio; for instance, the TrafficLicencingSysV4.0-AdpTR7531 appears to be is more favourite project when both *Mean* of Scores and *Mean* of ranking outcomes is considered.

	Economic			Social			Environment		*Mean*		
Alternatives / Projects	Rank	**Score**	.	Rank	**Score**	.	Rank	**Score**	*Mean* of Rank	***Mean* of Score**	
ConditionNotebookV2-AdpLT9765	7	0.624		7	0.624		7	0.624	2.1	**0.19**	
KioskAutomatesVehicleLicensing-AdpLT2319	2	0.874		2	0.874		2	0.874	0.6	**0.26**	**2nd**
ManagementSystem-AdpIT963	5	0.722		5	0.722		5	0.722	1.5	**0.22**	
SmartLibraryWebsite-AdpIT7861	4	0.745		4	0.745		4	0.745	1.2	**0.22**	
StatisticsPortsSecuritySystem-AdpLT7801	6	0.658		6	0.658		6	0.658	1.8	**0.20**	
TrafficLicencingSysV4.0-AdpTR7531	1	0.892		1	0.892		1	0.892	0.3	**0.27**	**1st**
VisitorReceptionSystem-AdpIT431	3	0.761		3	0.761		3	0.761	0.9	**0.23**	**3rd**

In the second part of this portfolio policy 8, the above spreadsheet is further equipped with *priority* definitions to automatically calculate the impact of priority on scores. This allowed incorporation of further priorities to individual sustainability related scenarios. So, this allowed prioritising the score of each scenario. The following calculations show the effect on defining priorities.

Prioritised Score	**2**			**7**			**1**			
	Economic			Social			Environment		Outcome	
Alternatives / Projects	**Score**	Priority Score	.	**Score**	Priority Score	.	**Score**	Priority Score	**Total Score**	**Prioritised Total Score**
ConditionNotebookV2-AdpLT9765	0.62	1.2		0.62	4.4		0.62	0.6	**1.87**	6.24
KioskAutomatesVehicleLicensing-AdpLT2319	0.87	1.7		0.87	6.1		0.87	0.9	**2.62**	**8.74**
ManagementSystem-AdpIT963	0.72	1.4		0.72	5.1		0.72	0.7	**2.17**	7.22
SmartLibraryWebsite-AdpIT7861	0.75	1.5		0.75	5.2		0.75	0.7	**2.24**	7.45
StatisticsPortsSecuritySystem-AdpLT7801	0.66	1.3		0.66	4.6		0.66	0.7	**1.97**	6.58

TrafficLicencingSysV4.0-AdpTR7531	0.89	1.8		0.89	6.2		0.89	0.9		**2.68**	**8.92**
VisitorReceptionSystem-AdpIT431	0.76	1.5		0.76	5.3		0.76	0.8		**2.28**	**7.61**

The following datasets show the complete picture of *Median*, *Mode* and *Mean* calculations of the cases discussed above.

Combined view of the Application of Prioritised Score

	Median		*Mode*		*Mean*		
Alternatives / Projects	**Score *Median***	**Prioritised Score *Median***	**Score *Mode***	**Prioritised Score *Mode***	**Score *Mean***	**Prioritised Score *Mean***	
ConditionNotebookV2-AdpLT9765	**0.62**	**1.25**	**0.62**	**#N/A**	**0.62**	2.08	
KioskAutomatesVehicleLicensing-AdpLT2319	**0.87**	**1.75**	**0.87**	**#N/A**	**0.87**	**2.91**	**2nd**
ManagementSystem-AdpIT963	**0.72**	**1.44**	**0.72**	**#N/A**	**0.72**	2.41	
SmartLibraryWebsite-AdpIT7861	**0.75**	**1.49**	**0.75**	**#N/A**	**0.75**	2.48	
StatisticsPortsSecuritySystem-AdpLT7801	**0.66**	**1.32**	**0.66**	**#N/A**	**0.66**	2.19	
TrafficLicencingSysV4.0-AdpTR7531	**0.89**	**1.78**	**0.89**	**#N/A**	**0.89**	**2.97**	**1st**
VisitorReceptionSystem-AdpIT431	**0.76**	**1.52**	**0.76**	**#N/A**	**0.76**	**2.54**	**3rd**

5.5 Conclusion: Selection of Scenarios and Outcome

This research resulted in the definition of project portfolio selection evaluation criteria priorities based on the different levels of portfolio balancing needs. This was made possible by working closely with portfolio managers and policy makers. In this research, thirteen distinctive scenarios of evaluation criteria's priorities specifications were defined, where each of the scenarios enabled decomposition of the project portfolio selection decision-making problem into phases. These scenarios were considered to be sufficient by the cases study organisation. However, this is not a restriction on other organisations to use the same number of scenarios and the process remain the same even if other organisations increase or decrease the scenarios depending on individual organisational needs. In this research, by working with ADP portfolio experts five different levels of priorities, i.e. in terms of hierarchy / pair wise comparisons, were specified i.e. the extremely most important is the highest required criteria priority, followed by most important, medium important, less important and extremely less important.

The scenario 1 is specified as a general scenario. Here, sustainability wasn't considered as the main priority. The sustainability related factors were given less

priority but kept above the project commercial value, which was given the least priority. The case study organisation of this research was a very large public/government organisation; and for them, commercial value is never that important. However, such situations were dealt in other scenarios. In scenario 2, the importance was given to project success and planning and were taken as top most criteria. This is to be noted here that in this second scenario again sustainability wasn't considered as the main factor. This was again primarily done to see the outcome of projects selection under normal circumstances where project success and completing are extremely important in comparison with sustainability. In scenario 3, operational continuity is taken as main factor, as well as the aspects of project criticality. In this scenario again sustainability wasn't considered as an important factor. Similarly, the project commercial value kept its position as per the previous scenarios. Moreover, factors related to finances and risks were considered here as second most important factors, and project completion and planning as medium important. In scenario 4, all sustainability related criteria were given the priorities as extremely most important. Project finances and risks were considered as second most important factors, followed by project completion and planning. Project commercial value was given the very least priority to ensure that it has minimum impact on the project selections. The scenario 5 was specifically defined for cases, and especially for the private sector organisations, where project commercial value could be one of the most important priorities. The scenario 6 provided another distinctive view of criteria priorities where project completion and project planning related criteria were considered as the top key factors to support the decisions where crucial projects should be supported. In scenario 7, factors related to an organisation's operational continuity were given the top priority along with the sustainability as the second highest priority. After scenario four, in scenario 8 again sustainability was considered as the main priority to observe its impact as compared to the previous three scenarios. However, in contrast with scenario 4 where sustainability as also considered as top priority, in scenario project commercial value was placed at second highest priority. In scenario 9, project commercial value was bundled with sustainability. Moreover, while combining sustainability factors with project commercial value as high priorities, all other factors were consequently given least priorities other then project completion and planning that were defined as less important. In scenario 10, all factors were given equal importance. The scenario 11 permitted to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Similarly, scenario 12 permitted to priorities those projects that have positive societal implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. And finally, the scenario 13 is defined to specifically support environmental sustainability. The outcome of these scenarios definitions enabled to answer the forth research question of this research, which is discussed in Chapter 6 Section 6.8 onwards. Moreover, these scenarios enabled us to perform further sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of individual sustainably factors.

In terms of scenarios implementations, all of the above-summarised 13 scenarios were implemented, which eventually resulted in eight policies formulation. The policy 1 resulted in obtaining criteria specifications for ten scenarios with. They were found sufficiently covering all aspects of this research after working with the case study organisation's portfolio manages and policy makers. However, the number of

scenarios can be increased or decreased depending on individual organisational needs. This outcome of Policy 1 is then used for various judgments on individual scenarios as well as for the execution and evaluation of all remaining policies. The Policy 2 allowed selecting the best three projects from all of the scenarios. The main advantage of this policy is that it gives equal weightage to all of the scenarios. As a result, the portfolio managers are free to choose any number of top resultant projects, but for this research we had selected three. The policy 3 gave flexibility to the decision makers to base their portfolio selection decision either of the *Median* or *Mode* of the rankings for individual projects in all scenarios. The policy 4 gave further flexibility to the decision makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean, Median* or *Mode* of individual projects. This has proved to be very useful when the portfolio decision makers perceive one or more scenarios as an organisational priority. With respect to policy 3, this Policy 4 allowed incorporation of further priorities to individual scenarios. So, in addition to the calculation of *Mean, Median* and *Mode* of individual project rankings in all scenarios, the policy 4 allows prioritising the score of each scenario. Furthermore, it was concluded that for policy 4 when defining priorities to individual scenarios, taking *Mean* of prioritised scores is the most suitable calculation. As the case study organisation in this research was having multi-dimensional attributes towards environment, social and economic sustainability, a rigorous sustainability analysis was conducted in policies 5, 6 and 7. Here, policy 5, allowed to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Similarly in policy 6, social sustainability is selected as the main optimisation factor. The policy 7 was developed to select projects based on the *Environmental* sustainability. Moreover, in order to see a combined effect of Economic, Social and Environmental sustainability on a portfolio of projects Policy 8 was developed and implemented. Furthermore in the extended implementation of policy 8, a mechanism of *priority* definitions was included to automatically calculate the impact of defining priority on rankings and scores.

In conclusion, the scenarios and policies implementations without priority definition showed that same projects got selected for both Median and Mean calculations. However, it has been found that calculating Mode in not a workable solution, as for distinct ranked values of projects, Mode cannot be calculated. Moreover, policies 4 and 8, provides individual as well as combined mechanism for project selection where sustainability has been considered as the main optimisation factor, and the Median and Mean of scores / ranks can be considered for further deep analysis and decision-making. Further, these policies 4 and 8 gave added control to the portfolio decision-makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the Mean of prioritised scores. This is especially convenient when the portfolio decision makers perceive one or more scenarios as an organisational priority.

In the next Chapter, the findings of practical evaluation are outlined along with the summary of overall research findings / contributions.

Chapter 6: Analysis and Discussion

This research resulted in proposing a Sustainable Project Portfolio Selection Process for the IT Projects namely "SPPS-IT". The SPPS-IT enabled the separation and execution of portfolio selection process into various distinct stages that included pre-processing, data/information flow, main process, post-processing and document stores (as discussed in Chapter 4 and 5 of this thesis). This SPPS-IT has been empirically evaluated in a case study organisation (details are provided in Chapter 5) by working with the portfolio managers and programmers. The implemented SPPS-IT process helped the portfolio managers to select project portfolios that maximised the criteria of interest of the organisation i.e. in line with their strategies, and which is also suitably balanced on both quantitative and qualitative parameters they chose. The research outcomes also provided the means to balance the portfolio using 8 different portfolio-balancing policies to select the most optimum portfolio as per of interest of the organisation. This Chapter discusses and summaries research findings in relation to the development and application of SPPS-IT, the use of Analytic Hierarchy Process technique for projects evaluation and portfolio-balancing policies in the light of aims and objectives of this research.

This research aimed to develop a sustainable PPS framework for the selection of IT projects, which is determined by corporate strategy plan and by considering sustainability as the main PPS optimisation factor along with balancing it with other PPS factors. The main research question of this research aim was: how can the PPS framework be improved for the selection of value added projects based on a balance approach to sustainability that is determined by both corporate and sustainability strategies. In an effort towards achieving the above defined research aim, the main research question of this research was decomposed into further research questions and their associated objectives based on the identified research gaps. Thus, further refined objectives and research questions are articulated, which are investigated and evaluated in this research and presented in the above chapters. In the following sections the summarised findings in relation to each research question and objective are presented.

6.1 Evaluation and Comparison of Existing PPS Frameworks

To answer the **research question 1** i.e. *to what extent the existing PPS frameworks are suitable for integrating sustainability?* A detailed investigation and comparison of existing PPS frameworks has been completed and presented in the Chapter 2 of this dissertation. This investigation was main focused on the review and analyse the exiting PPS frameworks to establish the possibility for incorporating sustainability for the evaluation of IT projects. In Chapter 2, it was concluded that there is an existence of abstract-level conceptual ideas on decision-making frameworks for sustainability. However, there is limited literature describing how sustainability can be considered in a project portfolio selection evaluation stage while

selecting IT projects. The following are the summary of findings of the literature survey.

This literature survey started by considering the aspects of corporate strategy and it was concluded that corporate strategy is associated with both organisational short- and long-term objectives. This is because corporate strategy is related to multiple actions in an organisation and an organisational *'strategy'* and/or *'strategic decisions'* are typically associated with various long- and short-term issues. Thus, in terms of the case study organisation, the organisational sustainability policies are linked with *corporate-level* strategy.

In relation to the implementation of sustainability strategy in an organisation (e.g. the case study organisation), it has been concluded that for the top management and/or business leaders of an organisations, it is important to have a clear and comprehensive sustainability strategy incorporated into organisational corporate-level strategy. Moreover, to achieve continuous reputation that is critical for long-term viability of an organisation, business leaders must incorporate sustainability aspect into corporate-level long-term strategies.

It has been evident via the literature survey as well as in the implementation phase (discussed in Chapter 5) that taking a balanced approach to sustainability has grater advantages and each part of the balanced sustainable development often supports each other. For example: (a) if organisations focus on social and environmental issues, profitability (economic growth) often follows; (b) social initiatives or an organisation usually have an impact on consumer behaviour and employee performance; and (c) environmental initiatives such as energy efficiency and lessening pollution can have a straight impact on dropping waste.

The literature survey also concludes that Green and Sustainable IT initiatives need to bring various cost savings opportunities. One of the means to achieve this is by prioritisation of projects. Thus, to achieve Green IT, organisations need to be selective in project selections that enable reduction of IT energy and operating costs, and reduce the environmental impact of IT practices.

While comparing the requirements of sustainable development and project (portfolio) management it has been noted that there are many challenges faced by the research community about integrating sustainability into project management. The organisations (like the case study organisation) need to be careful while generating sustainability policies as it can affect the proficiencies of the project manager(s) and the traditions how organizations make strategic plans and govern their projects.

The literature review on existing project portfolio management lifecycle models shows that only the "pre-project/initiation" phase is concerned with project(s) selection, where ideas are formulated and the business reviews are done. These business reviews evaluate on whether this is a feasible project. At this stage, all measureable elements of sustainability should also be considered and evaluated as complete package that can include various aspects of sustainability such as environmental, social and economic aspects. Moreover, an extensive theoretical and practical evaluation of related PPS frameworks enabled shortlisting of candidate PPS frameworks, which could possibly be extended and used in this research. The final selection, which was based on interviews data, gave a suitable PPS framework as starting point to customise, extend and also to include sustainability for the selection of IT projects.

6.1.1 Evaluation of Project Portfolio Selection Frameworks based on the Evaluation Criteria

The evaluation of project portfolio selection frameworks has been carried out in focused group workshops at ADP, which were scheduled for 5 consecutive days (two hours per day). The process of these focused group excises was as follows:

1. Pre-arrangement: Preparation and distribution of focused group related documents/information
    a. Facilitator (the researcher i.e. myself) distributed the following documents to all participants two weeks before the start of focused group session.

        i. PPS frameworks evaluation criteria with descriptions
        ii. Documents (research papers) describing each of the shortlisted 9 x PPS frameworks
        iii. Schedule and duration of focused group sessions
        iv. PPS frameworks evaluation table

    b. Facilitator has made himself available face-to-face or via telephone to answer any questions by the participants before the commencement of focused group sessions.

2. Focused group sessions: Conduct and outcome recording
    a. Each of the PPS frameworks was discussed for one hour as per the schedule (shown below).
    b. At the end of each one-hour session, participants completed the evaluation of PPS framework under discussion.
    c. The facilitator recorded the evaluation outcomes in the evaluation table.

3. Wrap-up and conclusion:
    a. The final one-hour session on day 5 was designated to review the final evaluation outcomes and sign off.

Focused Groups Sessions Schedule

Day/Date	Hour/Time	PPM Framework Evaluation
Day 1	Hour 1 1200-1300	PPS Framework 1: An integrated framework for project portfolio selection (Archer et al. 1999)
	Break 1300-1400	Lunch/refreshments
	Hour 2 1400-1500	PPS Framework 2: Portfolio Selection Methodology for a Nuclear Project (Strang, K. D. 2011)
Day 2	Hour 1 1200-1300	PPS Framework 3: Strategic framework for sustainable project portfolio selection and evaluation (Khalili, D. et al. 2013a). And, A hybrid fuzzy rule-based multi-criteria framework for sustainable project portfolio selection (Khalili, D. et al. 2013b)
	Break 1300-1400	Lunch/refreshments
	Hour 2 1400-1500	PPS Framework 4: Project Portfolio Selection Using Interactive Approach (Nowak, M., 2013)
Day 3	Hour 1 1200-1300	PPS Framework 5: Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology (Abbassi, M., et al. 2013)
	Break 1300-1400	Lunch/refreshments
	Hour 2 1400-1500	PPS Framework 6: A fuzzy set approach for R&D portfolio selection using a real options valuation model (Wang, J. et. al. 2007)
Day 4	Hour 1 1200-1300	PPS Framework 7: An R&D options selection model for investment decisions (Coldrick, S. et al. 2005)
	Break 1300-1400	Lunch/refreshments
	Hour 2 1400-1500	PPS Framework 8: An organizational decision support system for effective R&D project selection (Tian, Q., et al. 2005)
Day 5	Hour 1 1200-1300	PPS Framework 9: A mixed R&D projects and securities portfolio selection model (Fang, Y., et al. 2008)
	Break 1300-1400	Lunch/refreshments
	Hour 2 1400-1500	Discussions and Conclusions

Next the outcome of the evaluation of project portfolio selection frameworks is presented based on the above-mentioned evaluation criteria.

The outcome of focused group evaluation based on the evaluation criteria are presented here:

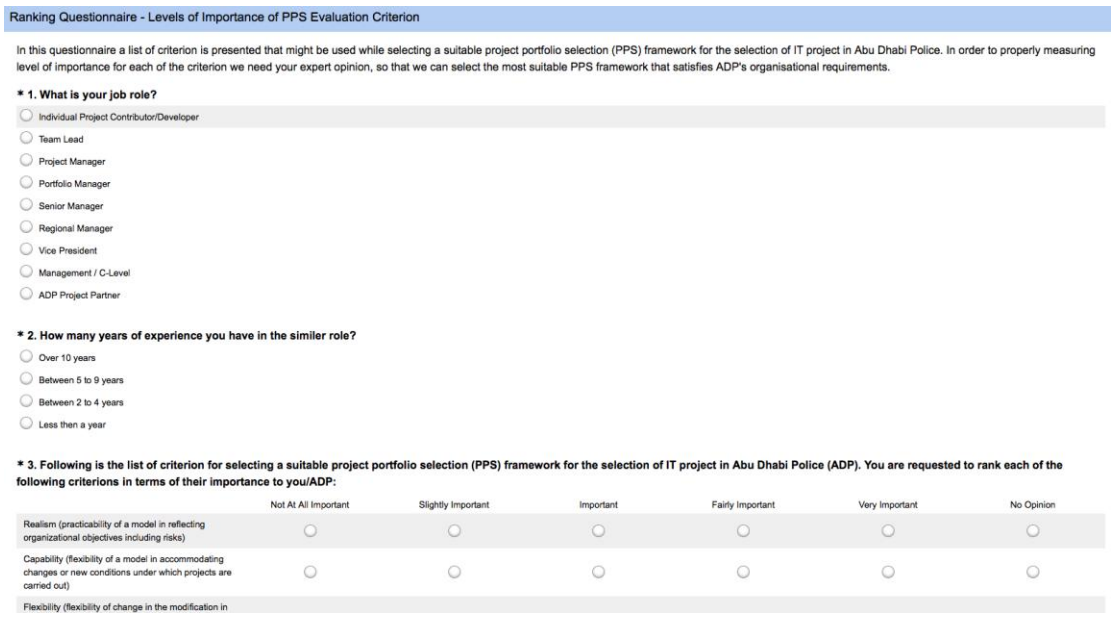
PPS Framework	PPS domain	Realism	Practical Reliability/ Accuracy	Capability to integrate with tools	Monitoring	Ease-of Use	Cost Effective	Comparability	Flexibility of change	Method Flexibility
Archer et.al. (1999)	Medium	High	Medium	High	Medium	High	High	Medium	High	High
Strang, K. D. (2011)	Medium	High	Medium	High	Low	Medium	Medium	Medium	Medium	High
Khalili, D. et. al. (2013ab)	Low	Medium	Low	Low	Low	Medium	Medium	Medium	Medium	Low
Nowak, M., (2013)	Low	High	NIL	Medium	Medium	Medium	Medium	Medium	High	Medium
Abbassi, M., et. al. (2013)	Medium	High	High	Medium	Medium	High	Medium	Medium	High	High
Wang, J. et. al. (2007)	Low	Low	NIL	Medium	Medium	Medium	Low	Medium	Medium	High
Coldrick, S. et. al. (2005)	Medium	Medium	Medium	High	Low	Medium	Medium	Medium	High	Medium
Tian, Q., et al. (2005)	Low	High	High	High	Medium	High	Medium	High	Medium	Medium
Fang, Y., et. al. (2008)	Medium	High	Medium	Medium	Low	Low	Low	Medium	Medium	Medium

As stated in the above criteria, the PPS frameworks evaluation comprised following distribution: High = 3 points, Medium = 2 points, Low = 1 points, NO (or NIL) = 0 points. The PPS frameworks evaluation outcome after applying this distribution is as follows:

PPS Framework	PPS domain	Realism	Practical Reliability/ Accuracy	Capability to integrate with tools	Monitoring	Ease-of Use	Cost Effective	Comparability	Flexibility of change	Method Flexibility
Archer et.al. (1999)	2	3	2	3	2	3	3	2	3	3
Strang, K. D. (2011)	2	3	2	3	1	2	2	2	2	3
Khalili, D. et. al. (2013ab)	1	2	1	1	1	2	2	2	2	1
Nowak, M., (2013)	1	3	0	2	2	2	2	2	3	2
Abbassi, M., et. al. (2013)	2	3	3	2	2	3	2	2	3	3
Wang, J. et. al. (2007)	1	1	0	2	2	2	1	2	2	3
Coldrick, S. et. al. (2005)	2	2	2	3	1	2	2	2	3	2
Tian, Q., et al. (2005)	1	3	3	3	2	3	2	3	2	2
Fang, Y., et. al. (2008)	2	3	2	2	1	1	1	2	2	2

6.1.2 Obtaining the Levels of Importance of each PPS Evaluation Criterion

After obtaining all of the criteria to evaluate PPS frameworks, the next step was to obtain the level of importance of each criteria to determine its weight. In order to measuring level of importance for each of the criterion experts opinions were collected from the project portfolio specialists at Abu Dhabi Police (ADP) with the help of a questionnaire, so that the most suitable PPS framework that satisfies ADP's organisational requirements could be selected.



Ranking Questionnaire - Levels of Importance of PPS Evaluation Criterion

In this questionnaire a list of criterion is presented that might be used while selecting a suitable project portfolio selection (PPS) framework for the selection of IT project in Abu Dhabi Police. In order to properly measuring level of importance for each of the criterion we need your expert opinion, so that we can select the most suitable PPS framework that satisfies ADP's organisational requirements.

*** 1. What is your job role?**

- Individual Project Contributor/Developer
- Team Lead
- Project Manager
- Portfolio Manager
- Senior Manager
- Regional Manager
- Vice President
- Management / C-Level
- ADP Project Partner

*** 2. How many years of experience you have in the similer role?**

- Over 10 years
- Between 5 to 9 years
- Between 2 to 4 years
- Less then a year

*** 3. Following is the list of criterion for selecting a suitable project portfolio selection (PPS) framework for the selection of IT project in Abu Dhabi Police (ADP). You are requested to rank each of the following criterions in terms of their importance to you/ADP:**

	Not At All Important	Slightly Important	Important	Fairly Important	Very Important	No Opinion
Realism (practicability of a model in reflecting organizational objectives including risks)						
Capability (flexibility of a model in accommodating changes or new conditions under which projects are carried out)						
Flexibility (flexibility of change in the modification in						

Figure 7: A screen shot of the questionnaire (available at https://www.surveymonkey.com/r/SCLKN8V)

In the questionnaire, the above list of criterions for selecting a suitable PPS framework for the selection of IT project in Abu Dhabi Police was presented and the respondents were asked to give their ranking. Overall, 10 respondents having various senior roles at ADP have filled the survey that include: two team leads, one project contributor, three project managers, two portfolio managers and two senior managers. Moreover, 60% of these respondents had over 10 years of experience in the same role, 30% had between 5-9 years of experience in the same role and only 10% had between 2 to 4 years of experience. None of the respondents have less than a year experience. The scale for rating importance is as follows which is used to calculate the ranking for each criterion:

Scale	Score
Not at all important	1
Slightly important	2
Important	3
Fairly important	4
Very important	5
No opinion	Not applicable (NA)

In order to calculate the final rankings for the criteria, the mode of the respondent responses is taken and then calculate the ranking results. For example, for Realism 6 of the respondents has rated as "Very Important" so the Result is "Very Important" with scale 5. Similarly, all the ranking are calculated using this calculation method, the resultant rankings (as an outcome of the questionnaire) are presented as following table:

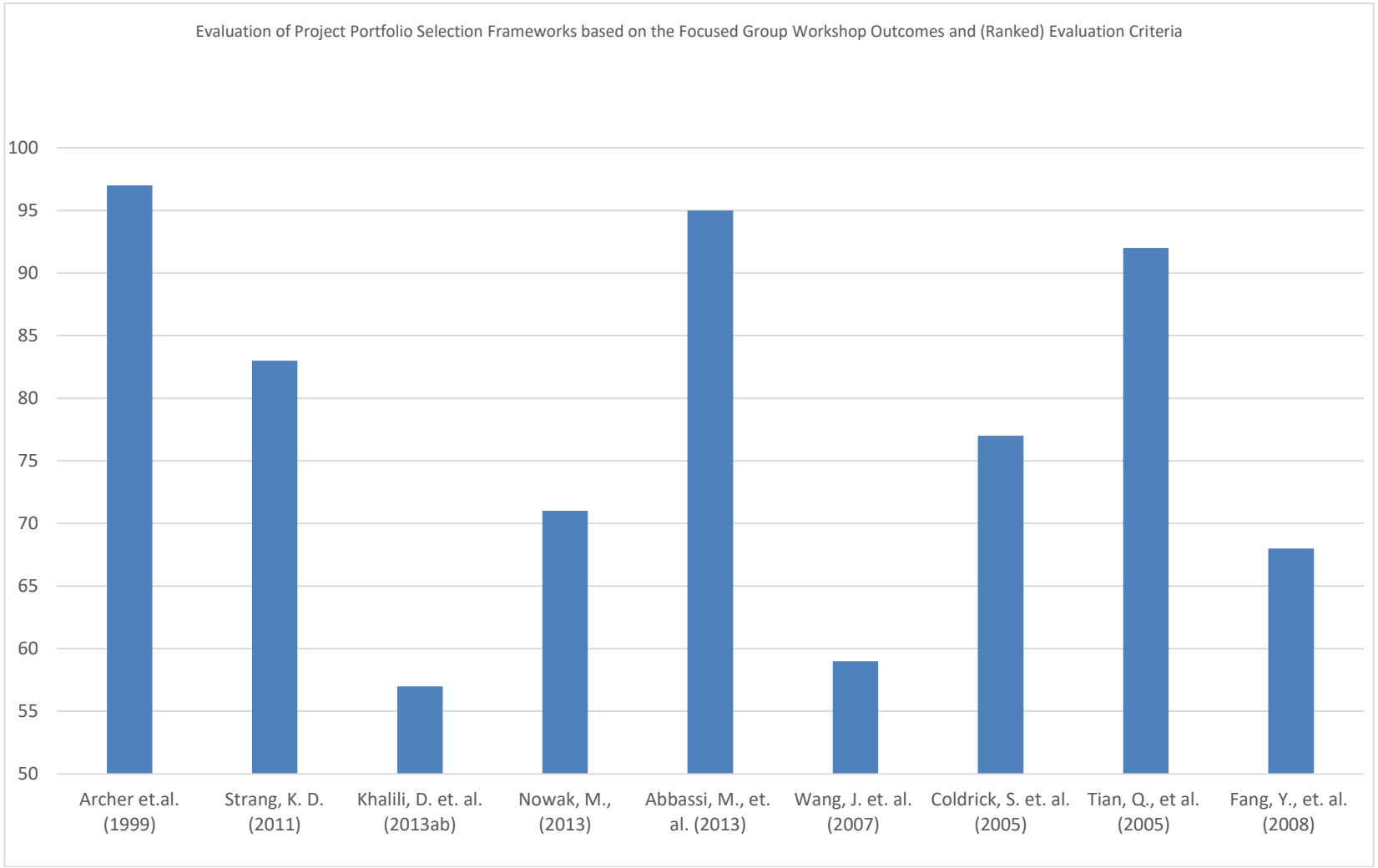
Rankings of Project Portfolio Selection Frameworks Evaluation Criteria

Score →	**1**	**2**	**3**	**4**	**5**	Total / 10
Criterion and Scales	Not at all important	Slightly important	Important	Fairly important	Very important	Mode Selection Results
Realism	0	0	1	3	6	**5**
Capability	0	0	3	5	2	**4**
Flexibility (of change)	0	0	6	3	1	**3**
Ease of Use	0	1	2	2	5	**5**
Cost Effective / Econometric Viabil.	0	0	5	3	2	**3**
Capability to integrate	0	0	6	2	2	**3**
Qualitative/Quantitative method flexibility	0	0	4	5	1	**4**
PPS domain/field	0	2	5	3	0	**3**
Practical Reliability/Accuracy	0	0	3	4	3	**4**

The following is the outcome of the evaluation of the project portfolio selection frameworks by the experts based on the evaluation criteria and after applying the ranking to the evaluation criteria using the obtained rankings / weightages.

Evaluation of Project Portfolio Selection Frameworks based on the Focused Group Workshop Outcomes and (Ranked) Evaluation Criteria

PPS Framework	PPS domain		Realism		Practical Reliability/ Accuracy		Capability to integrate with tools		Monitoring		Ease-of Use		Cost Effective		Comparability		Flexibility of change		Method Flexibility		Total Score
Ranking/Weightage →		**3**		**5**		**4**		**3**		**3**		**5**		**3**		**4**		**3**		**4**	**150**
Archer et.al. (1999)	2	6	3	15	2	8	3	9	2	6	3	15	3	9	2	8	3	9	3	12	**97**
Strang, K. D. (2011)	2	6	3	15	2	8	3	9	1	3	2	10	2	6	2	8	2	6	3	12	**83**
Khalili, D. et. al. (2013ab)	1	3	2	10	1	4	1	3	1	3	2	10	2	6	2	8	2	6	1	4	**57**
Nowak, M., (2013)	1	3	3	15	0	0	2	6	2	6	2	10	2	6	2	8	3	9	2	8	**71**
Abbassi, M., et. al. (2013)	2	6	3	15	3	12	2	6	2	6	3	15	2	6	2	8	3	9	3	12	**95**
Wang, J. et. al. (2007)	1	3	1	5	0	0	2	6	2	6	2	10	1	3	2	8	2	6	3	12	**59**
Coldrick, S. et. al. (2005)	2	6	2	10	2	8	3	9	1	3	2	10	2	6	2	8	3	9	2	8	**77**
Tian, Q., et al. (2005)	1	3	3	15	3	12	3	9	2	6	3	15	2	6	3	12	2	6	2	8	**92**
Fang, Y., et. al. (2008)	2	6	3	15	2	8	2	6	1	3	1	5	1	3	2	8	2	6	2	8	**68**


Evaluation of Project Portfolio Selection Frameworks based on the Focused Group Workshop Outcomes and (Ranked) Evaluation Criteria
100
95
90
85
80
75
70
65
60
55
50
Archer et.al. (1999)
Strang, K. D. (2011)
Khalili, D. et. al. (2013ab)
Nowak, M., (2013)
Abbassi, M., et. al. (2013)
Wang, J. et. al. (2007)
Coldrick, S. et. al. (2005)
Tian, Q., et al. (2005)
Fang, Y., et. al. (2008)

The above evaluation outcome shows that the three frameworks have scored the maximum in relation to the need and defined aims of this research. These frameworks are as follws:

1. "Selecting balanced portfolios of R&D projects with interdependencies: A Cross-Entropy based methodology" (Abbassi et al., 2013),
2. "An organizational decision support system for effective R&D project selection" (Tian, Q., et al., 2005); and
3. "An integrated framework for project portfolio selection" (Archer and Ghasemzadeh 1999);

In the next stage of this research, the selected portfolio managers of ADP were interviewed to select the preferred PPS framework; details are presented in the next section.

6.1.3 Final Evaluation of selected Project Portfolio Selection Frameworks by the Portfolio Managers

To moving forward towards finding the best suitable existing PPS framework for ADP for the evaluation of IT projects project/portfolio managers were interviewed. Following were the intended findings, outcomes and related interview questions:

Findings # 1: Strategic requirement of PPS framework at ADP

Intended outcome: Identification of the ways PPS is being done or should be done at ADP for the selection of IT projects

Question 1: Procedure for Projects Selection at ADP? (Intro. General)

Detailed Question/Description: While selecting projects do you use any specific (PPS) selection criteria or it is just a random project selection by the top management?

Key Words / Codes: Criteria based project selection; Random project selection

Question 2: Is PPS should relate to organizational strategy? (Realism)

Detailed Question/Description: To what magnitude your project selection is normally related to organizational strategy and do you believe that strategic alignment in selecting projects is to be more important than financial considerations?

Key Words / Codes: PPS at ADP reflects organizational objectives; PPS at ADP does not reflects organizational objectives; PPS only partially reflects organizational objectives

Findings # 2: Reliability or Capability requirement of PPS framework at ADP

Intended outcome: The capability needs that a PPS framework should have at ADP for the selection of IT projects

Question 3: Capability to integrate with relevant tools? (Capability)

Detailed Question/Description: Do you use various tools or systems while performing PPS? and do you think it is important that the selected PPS model should be easily modified if trial applications (e.g.

visual tools or changing the GUI tool to a spread sheet tool for evaluation) require changes.

Key Words / Codes: PPS must be capable to integrate with tools and systems; PPS may not be capable to integrate with tools and systems; PPS must not allow integration with other tools and systems

Question 4: Need of Decision maker's involvement? (Monitoring)

Detailed Question/Description: Is there any particular 'decision maker(s)' involvement for the selection of projects for controlling and overriding portfolio selections when required? (This means that the decision maker can have his opinion considered based on his/her previous experience or up to date knowledge of the proposed project)

Key Words / Codes: Decision's Maker involvement is necessary; Decision's Maker involvement is encouraged but no necessary; No decision maker involvement

Findings # 3: Economic requirement of PPS framework at ADP

Intended outcome: The need of easiness in use and economic viability a PPS framework should provide at ADP for the selection of IT projects

Question 5: The ease in using a PPS framework? (Ease of use)

Detailed Question/Description: Is the PPS framework will be used by many people having different skill set? Will it be appropriate if ADP employees will need to take special training or learn new skills to perform project selection?

Key Words / Codes: PPS should be easy of use for everyone in ADP; Some training can be arranged for ADP employees to perform PPS; Detailed training and learning new skills should not be problem

Question 6: Econometric Viability of PPS framework? (Cost Effective)

Detailed Question/Description: When you select candidate projects do you perform any pre-screening of projects to reduce the cost of PPS process? And, does it cost of gathering, storing, and arranging information in the form of useful reports or proposals to perform PPS process matters in ADP.

Key Words / Codes: PPS should be cost effective; PPS activity cost can be moderate; PPS activity cost doesn't matter at all in ADP

Findings # 4: Integration requirement of PPS framework at ADP

Intended outcome: The kind of flexibility a PPS framework provides or should provide at ADP for the selection of IT projects

Question 7: Required comparability of projects? (Comparability)

Detailed Question/Description: How many projects are usually running at the same time in your department and are these projects are usually different in nature?

Key Words / Codes: Total Comparability (i.e. model is applied to multiple types of projects); Moderate Comparability (i.e. model is

applied to almost similar types of projects); No Comparability (i.e. model is applied to similar types of projects)

Question 8: Size of projects usually considered in PPS? (Applicability)

Detailed Question/Description: How would you describe the scale of projects in ADP?

Key Words / Codes: Large-scale projects only; Medium to large-scale projects; Small to medium projects; Small projects only

Question 9: Need to add new Criteria and Constraints for PPS (Flexibility of Change)

Detailed Question/Description: To what extent is it important that a model should be flexible enough to respond to changes in the conditions under which projects are carried out and robust enough to accommodate new criteria and constraints?

Key Words / Codes: Highly flexible; Fairly flexible (e.g. model responds to changes but cannot accommodate new criteria, or vice versa); No flexibility

Question 10: Evaluation of both Qualitative and the Quantitative in project selection? (Method flexibility)

Detailed Question/Description: IS the selected PPS model need to be flexible that it must be able to accommodate both qualitative or exclusively quantitative project selection parameters? Or just considering one of qualitative or exclusively quantitative parameters is enough?

Key Words / Codes: Both qualitative and exclusively quantitative parameters; only qualitative parameters; Only quantitative parameters

Findings # 5: Evaluation of PPS frameworks based on project scenarios from ADP

Intended outcome: Narrowing down to a PPS framework from interviewees' expert knowledge, which can be used in ADP for IT projects selection.

(Note-: The interviewees' answers to this section should match to the findings of above section; and therefore, should verify the selection of one final PPS framework)

Question 11: PPS framework close to reality practices in ADP?

Detailed Question/Description: You have practically applied the given PPS frameworks on the selected old ADP's PPS case, is the outcome matching to the original portfolio decision? Which of the selected PPS frameworks is more close to how you perform PPS at ADP and why?

Key Words / Codes: Name(s) of the Frameworks;

Question 12: Preferred PPS framework for ADP?

Detailed Question/Description: Despite the way how PPS is actually performed at ADP, Which of these selected PPS frameworks do you think will be more appropriate for ADP and why?

Key Words / Codes: Name of the Frameworks

Findings # 6: Demographic details of Interviews

Intended outcome: Classification details of interviews to deeply analyse the interview outcomes

Question 13: Work experience as project/portfolio manager?

Detailed Question/Description: How many years of overall portfolio manager experience you have including working with other organizations?

Key Words / Codes: Experienced (15 or more years); Mid-level experience (7 to 14 years); Earlier career (3 to 6 years); In-experienced (less then 3 years)

Question 14: Age Bracket?

Detailed Question/Description: In which age bracket you are?

Key Words / Codes: 50 years or more; Between 40 to 49 years; Between 30 to 39 years; Less then 30 years

Question 15: Experience of PPS process?

Detailed Question/Description: How many types and what sizes of projects you have managed in the past, which also went through the PPS process?

Key Words / Codes: Experienced (10 or more medium to large-scale projects); Mid-level experience (6 to 9 projects medium to large-scale projects); In-experienced (less then 5 projects or zero medium to large-scale projects)

6.1.3.1 Interview data capturing and processing

The interviews conducted at ADP were recorded and then processed via NVivo. The following are the screenshots showing the processing of interviews data.

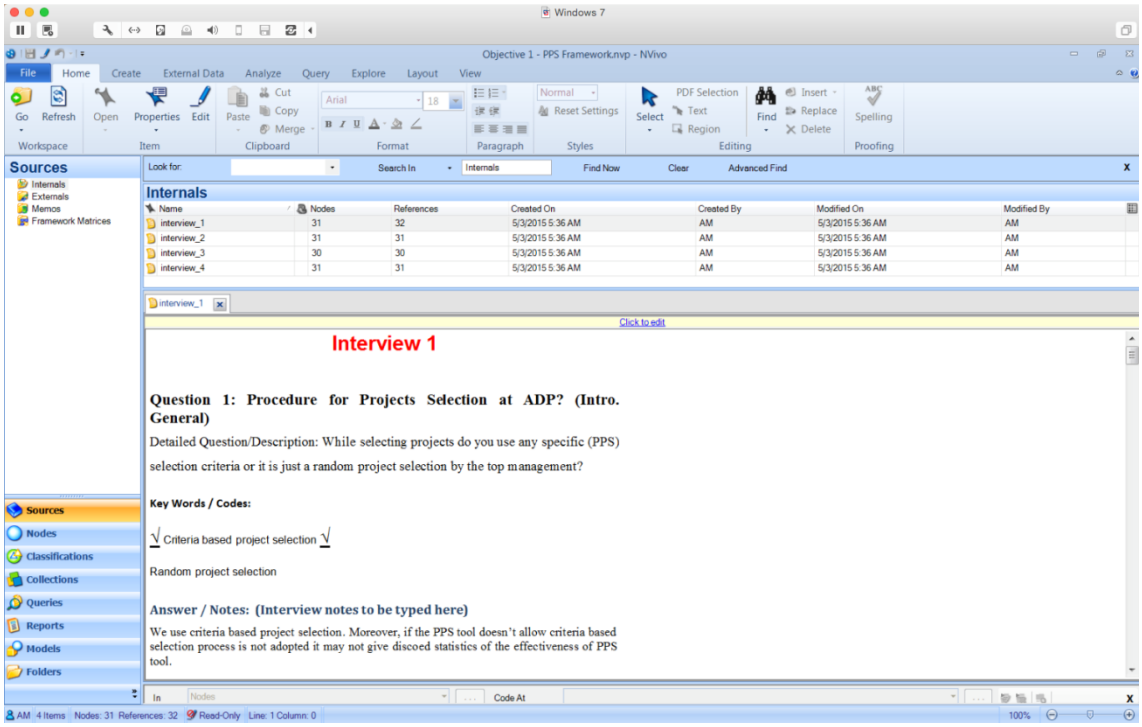


Figure 8: Imported the interview transcripts in NVivo software for nodes/classification

The following screenshot shows how various nodes and references were created to analyse the interview data.

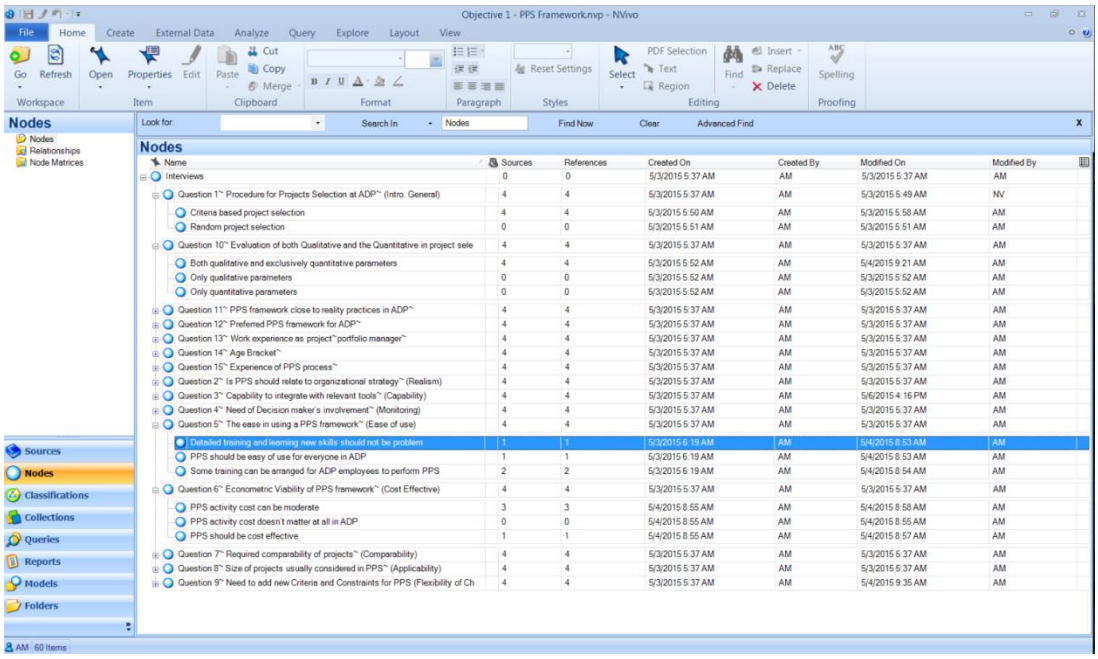
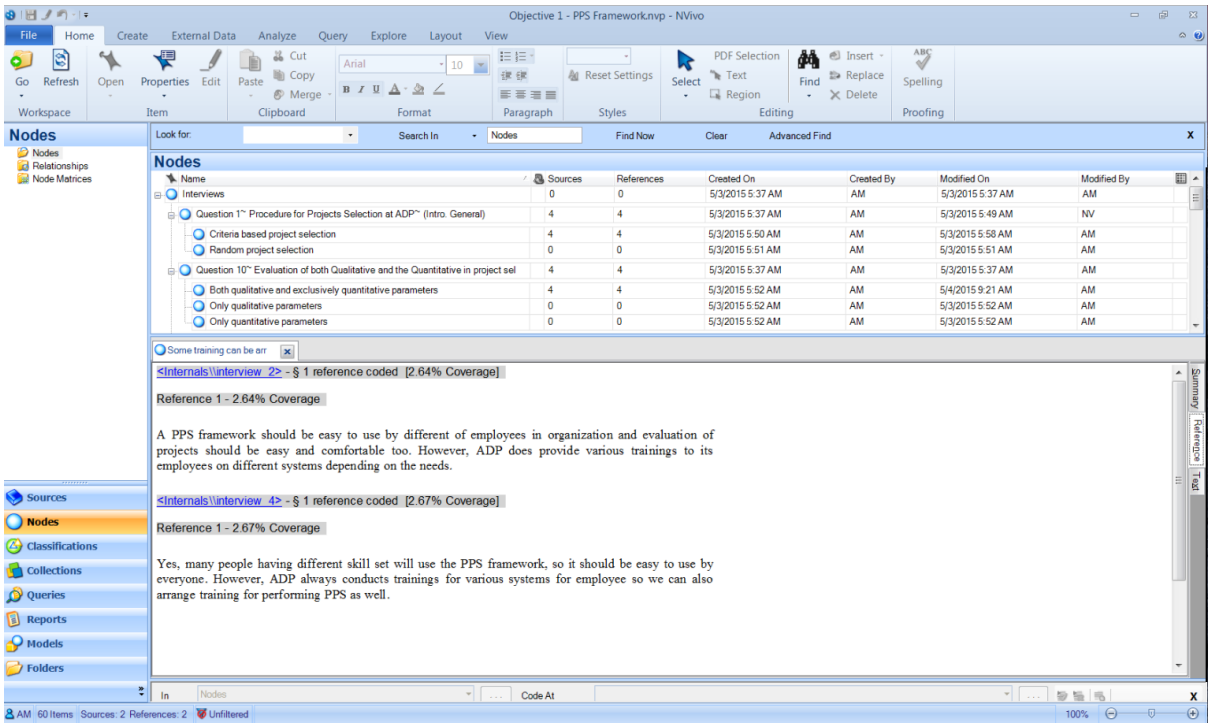


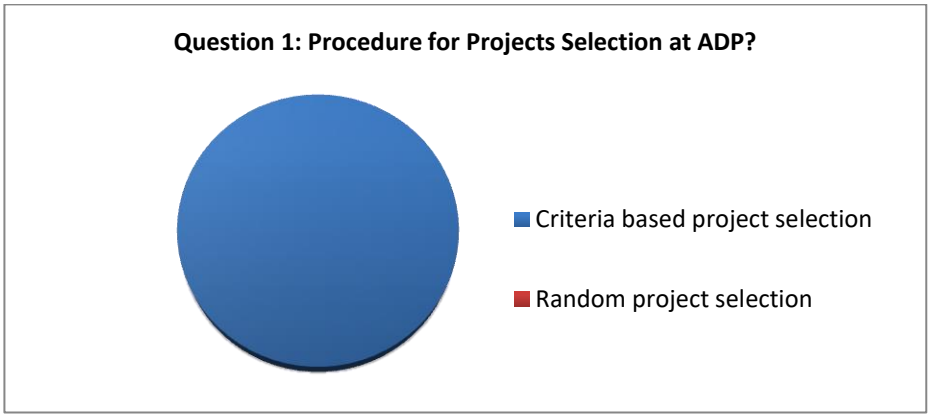
Figure 9: Creating nodes classification in NVivo using the keywords/codes

The following screenshot shows the data analysis carried out via NVivo. The summaries of the results are presented and discussed using pie charts in the next section.

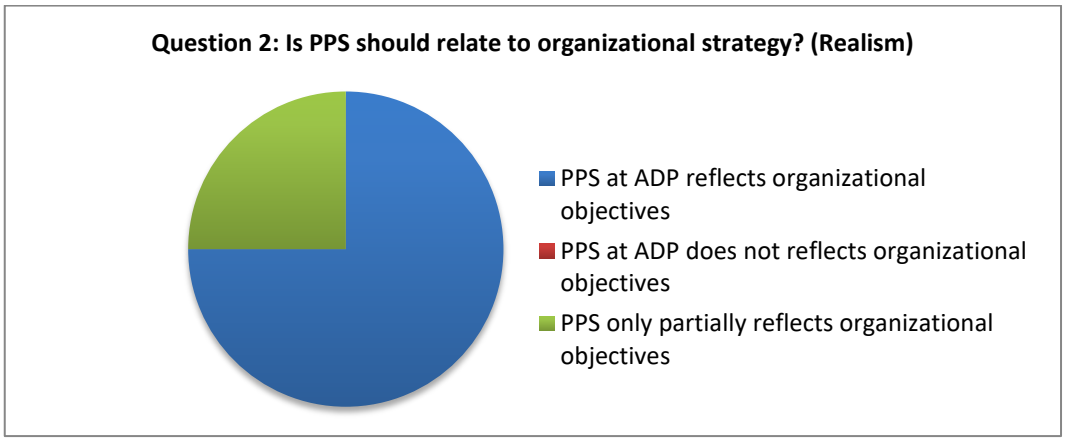


6.1.3.2 Interview data analysis and outcomes

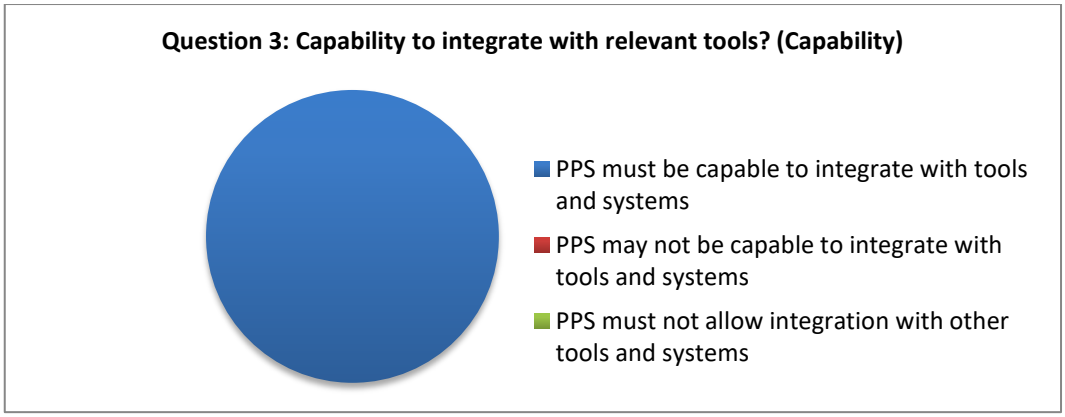
The outcomes of interviews are presented s follows:



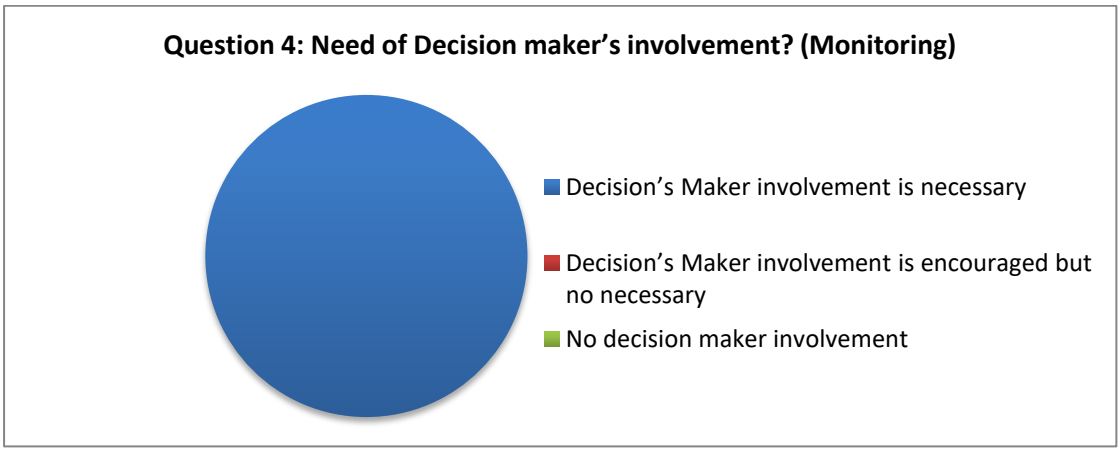
For the question 1, the above result shows that all (100%) of the ADP interviewees said that they follow a criterion-based procedure for projects selection at ADP instead of random project selection.



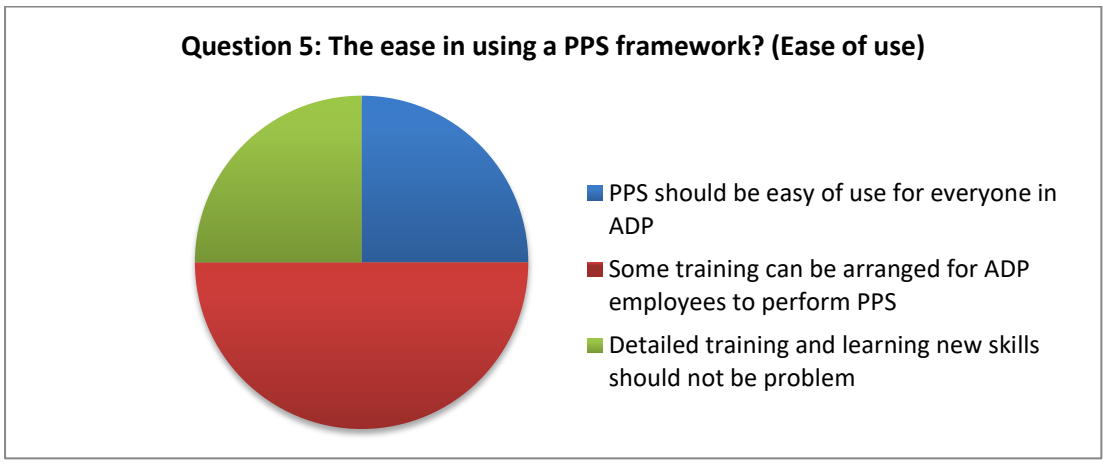
It was important to understand about ADP's organizational strategy and to what extent ADP's project selection is normally related to organizational strategy, and also if at ADP the strategic alignment in selecting projects is to be more important than financial considerations. The outcome of the interview question (Question 2) as pie chart shows that 75% of the respondents said that PPS at ADP truly reflects organisational objectives, whereas 25% declared that PPS at ADP only partially reflects organisational objective. Thus, it can be concluded that for a PPS framework to be followed (or selected) at ADP its strategic alignment in selecting projects is important.



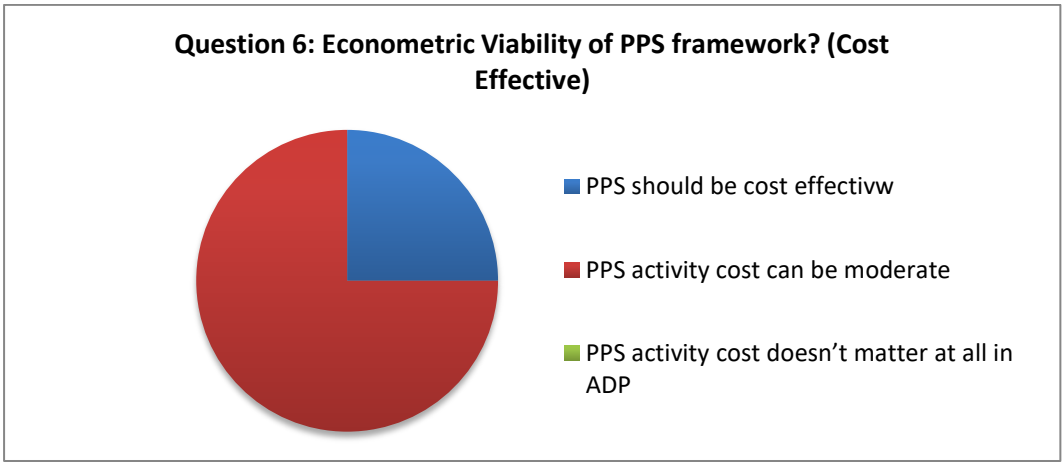
The data analysis of Question 3 represented in the following pie chart revealed that 100% of the interviewees agreed that it is important that the selected PPS model should be easily modified if trial applications require changes.



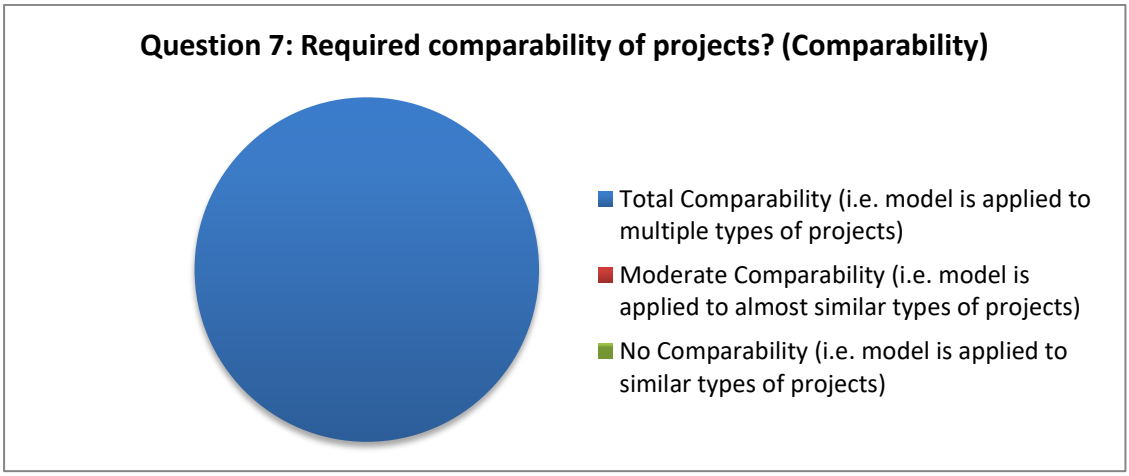
In PPS process, it is not uncommon for organisations to include one or more 'decision makers' for controlling and overriding portfolio selections when required. This usually happens when there is a conflict or the project managers have limited knowledge/details of the projects. When the interviewees were asked about the importance of including a decision maker in the PPS process 100% of them said that 'decision maker(s)' involvement for the selection of projects for controlling and overriding portfolio selections in necessary.



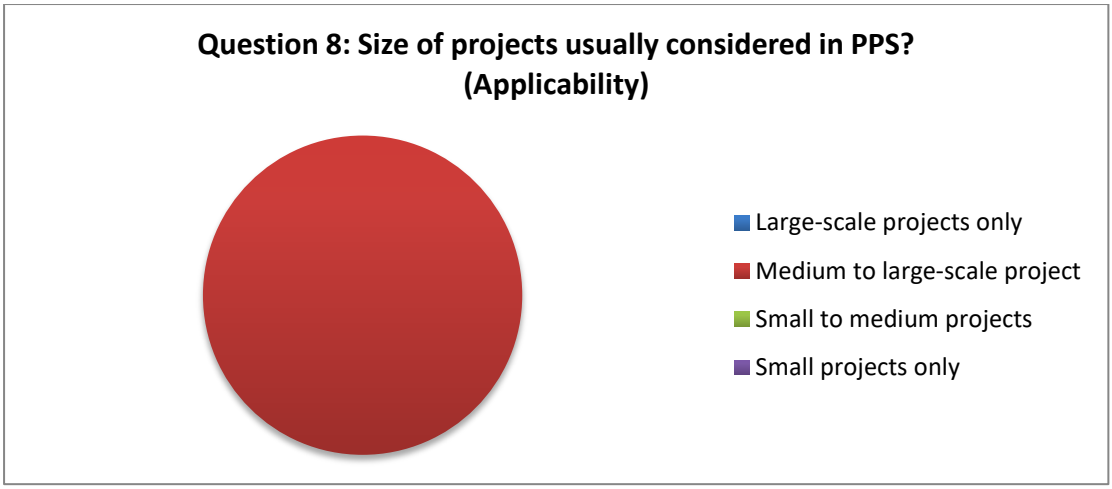
When the interviewees were questioned about their opinion on the easiness of arranging a special training or asking ADP employees learn new skills to perform project selection, 50% of them said that some training could be arranged, 24% said that using a PPS framework should be easy for employees so they want an easy of use PPS framework. Only 25% said that conducting a detailed training and learning new skills should not be a problem for the ADP employees.



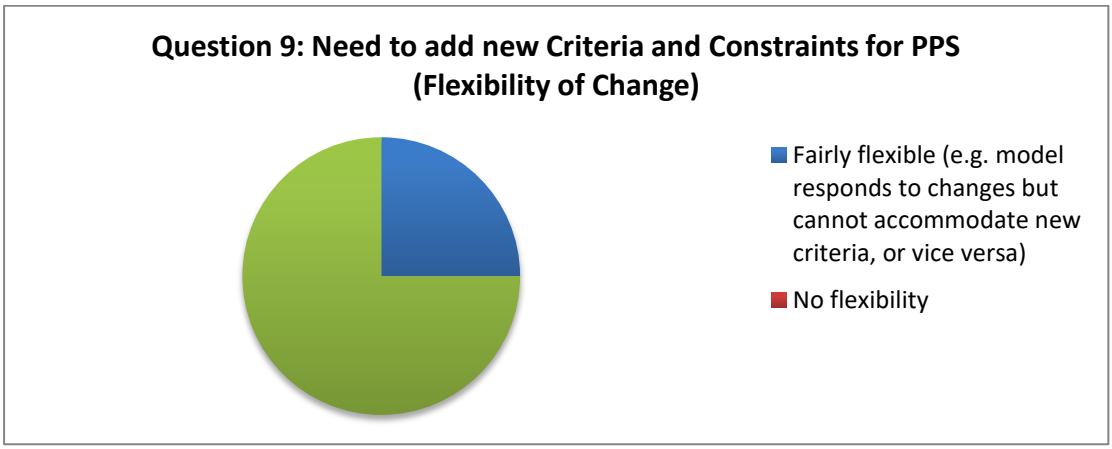
The above chart show that 75% of the interviewees think that the cost of gathering, storing, and arranging information in the form of useful reports or proposals to perform PPS process should be moderate, and 25% of the interviewees strongly suggested that the PPS activity should be cost effective.



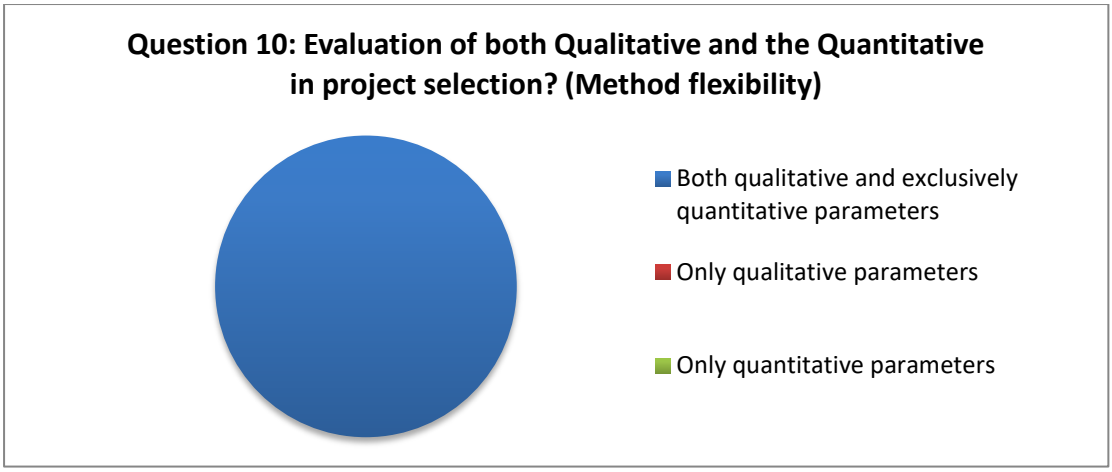
The interview outcomes show the selected PPS framework should provide Total Comparability, as there many projects that run in ADP and all of them are usually different in nature.



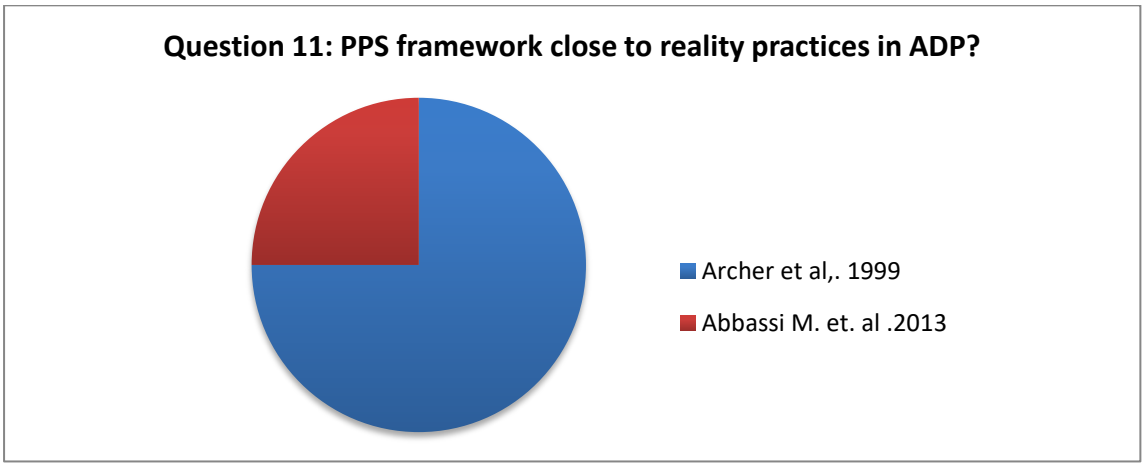
The above outcome about the scale of projects in ADP (Question 8) show that the selected PPS framework should be applicable to medium to large scale projects as 100% of the interviewees confirmed that the projects running in ADP vary from medium to large-scale projects.



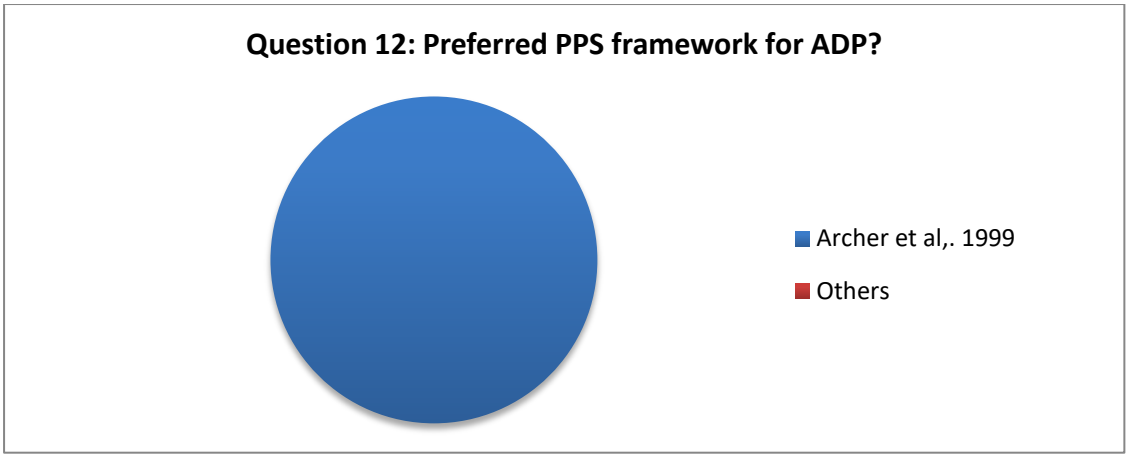
ADP was interviewed to know the extent to which is it important for them that a model should be flexible enough to respond to changes in the conditions under which projects are carried out. This question also included the need of PPS framework of being robust enough to accommodate new criteria and constraints. As a response to this question, 75% of the interviewees suggested that they would like a highly flexible framework and 25% demanded for at-least fairly flexible PPS framework. As none of the interviewees agreed for a non-flexible framework; and therefore, selecting a flexible PPS framework is important for ADP.



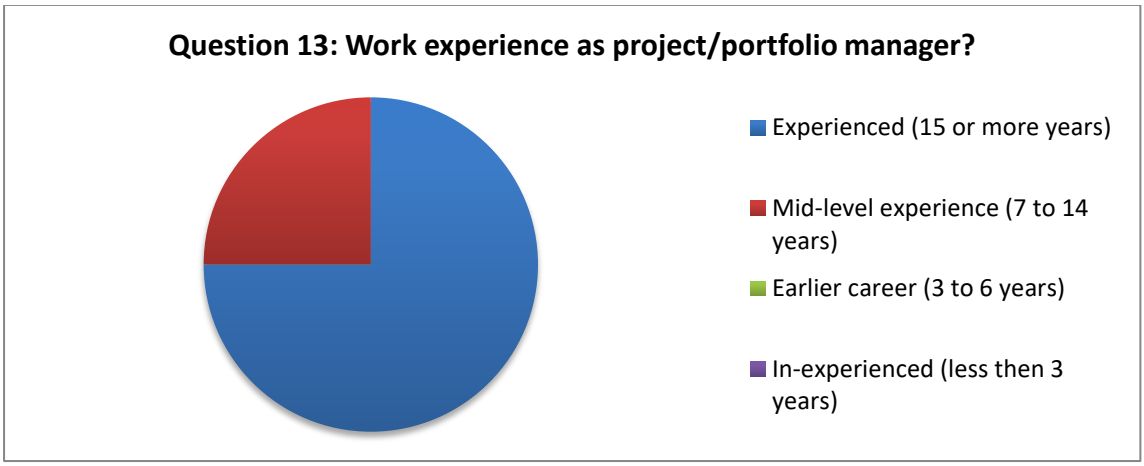
As the above chart shows that 100% of the interviewees were in the favour of using both qualitative or exclusively quantitative project selection parameters in the selected PPS framework for ADP. Thus, selecting a framework for ADP that has the capability to include both qualitative or exclusively quantitative project selection parameters is important.



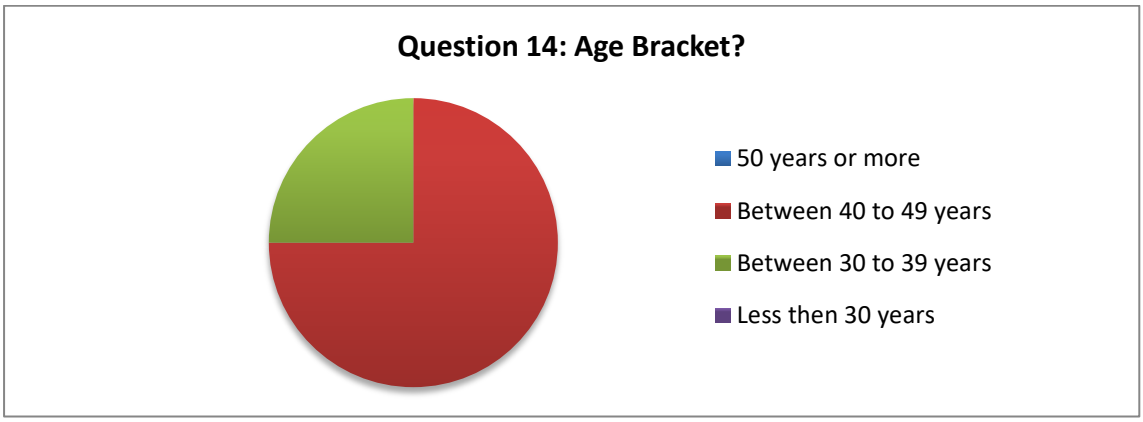
The above chart shows that after having practically applied the given PPS frameworks on the selected old ADP's PPS case studies 75% agreed that the PPS framework presented by (Archer et. al., 1999) is more close to how PPS activates are performed at ADP and the outcomes of applying that framework are matching to the original portfolio decisions that they took in the past.



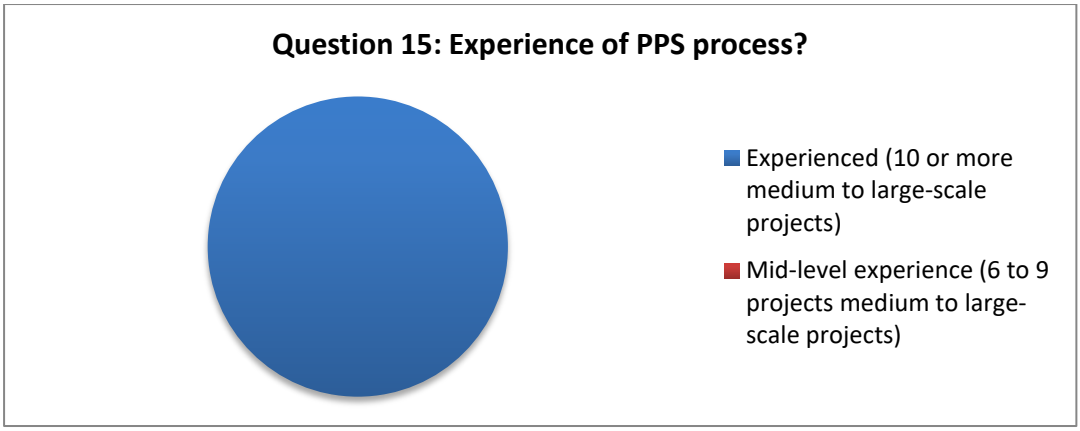
The above chart shows that 100% of interviewees selected the PPS framework presented by (Archer et. al., 1999) as more appropriate for ADP. The interviewees selected none of the other frameworks.



Demographics data of the interviewees were also collected. As shown in the above chart 75% of the interviewees were highly experienced (i.e. 15 years or more experience) and 25% of the selected interviewees were having mid-level (7 to 14 years of experience). No in-experienced or early career project portfolio managers or ADP employees were included in this investigation.



As shown in the above chart 75% of the interviewees were between the age of 40 and 49 and only 25% of the selected interviewees were between the age of 30 and 39.



Demographics data about the project experiences of the interviewees were also collected. As shown in the above chart 100% of the selected interviewees were highly experienced in their field and at-least worked on 10 projects. The main conclusion of this entire activity was that the PPS framework presented by (Archer et. al., 1999) has been selected as more appropriate to extend and to include sustainability for the selection of IT projects. Based on this and the conclusions of the literature review and identified shortcomings, this research came up with a sustainable framework/model for IT projects portfolio selection.

6.2 The Sustainable Project Portfolio Selection Process for the IT Projects (SPPS-IT)

The literature review (in Chapter 1) helped concluding that to accept or reject a project based on early warning a "pre-project and / or initiation" phase can be used while integrating sustainability into project portfolio selection. This integration of sustainability assessment into project portfolio can help in making a society more sustainable. The **research question 2** of this research stated: *How can sustainability be considered as an evaluation stage in a PPS framework?* And to answer this research question the following objective was planned: Determine how sustainability can be integrated into a PPS framework as a stage for the evaluation of IT projects. In this regard, this research resulted in proposing a Sustainable Project Portfolio Selection Process for the IT Projects (SPPS-IT). The proposed SPPS-IT process proved to be helpful in selecting a project portfolio that maximises the criteria of interest to the selected case study organisation i.e. in line with the cooperate strategy and sustainability strategy, and which was also suitably balanced on both quantitative and qualitative parameters they preferred.

The overall SPPS-IT process has been divided into various distinct pre-processing, data/information flow, main stages, post-processing and document stores. The pre-processing stages of SPPS-IT included economic, environment and social factors, which resulted in the specification of sustainability constraints and generation of sustainability criteria. Here the economic dimension of sustainability in project selection ensured that the project has considered economic implications so that negative impacts on wider economy are either avoided or mitigated during the life of the project. The environmental dimension of sustainability in project selection ensured that project has considered environmental implications so that negative impacts on environment are either avoided or mitigated during the life of the project. The social dimension of sustainability in project selection ensured that project maintains social stability - i.e., measuring that has the project considered social

implications so that negative impacts on society are either avoided or mitigated during the life of the project. Moreover, it has also considered issues relate to the level and degree of acceptability of a project to the community, the local representatives, the executing agency etc. Weak acceptability by anyone or more of these parties has the risk of compromising long-term sustainability of a project. Further, the outcome of these three pre-process activities i.e. *economic factors*, *environment factors* and *social factors* are combined to in the specification of *sustainability constraints.* Moreover, it was investigated that for the application of ADP sustainably evaluation process there is a need to include a *Sustainability Criteria* for project's evaluation that can provide the data on sustainability factors for that project. The pre-process activity of *generating sustainability criteria* took input from *sustainability strategy and sustainability constraints*. The resultant *sustainability criteria* were then used to perform sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of the sustainably factors that were likely to impact, either positively or negatively. Finally, another aspect of pre-processing stages included *functional unit decision-making*, in which project evaluation and operational constrains were defined based on the organisational cooperate strategy.

Once the initial pre-screaming and specification of proposals were completed, the SPPS-IT, performed detailed (actual) *evaluation of projects proposals.* Using these *evaluation* constraints interactions among the various projects were measured, including interdependencies, division of resources, planning etc. The main constraints that have been evaluated included *criticality*, *project success*, *benefits*, *strategic improvement, efficiency improvement, risks, operational continuity, financial value, commercial value,* and *technical complexity* of the portfolio projects.

Finally, when all the projects in a portfolio have been evaluated, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects using different portfolio-balancing policies. These portfolio-balancing policies helped portfolio managers in achieving a portfolio that met both the strategic and sustainability objectives of the organisation optimally. Therefore, while applying a portfolio-balancing policy all relevant evaluation information of the projects and evaluation factors scoring /ranking must be made available to allow decision makers to evaluate the portfolio and make informed decisions. Moreover, in some cases (where applicable) portfolio policies also provide the possibility for final judgmental adjustments through defining further priorities. More detailed conclusions on portfolio policies and the benefits obtained by including priorities are provided in the later sections of this chapter.

The proposed SPPS-IT process can also be applied in other originations and their PMO office and/or project portfolio managers are free to choose the evaluation technique they find is/are the most suitable for a stage. This is to allow the decision makes to utilise a desired subset of available evaluation methodologies in easy and logical manner. Moreover, in some of the cases the users may omit a stage if that process was already completed to simplify and expedite the project portfolio selection process.

6.3 Sustainability Evaluation Criteria

In today's world adhering sustainability practices are important for organisational reputation and it is imperative that organisations improve their sustainability practices

by reducing the adverse societal, environmental and economic impacts from project activities. Due to such causes, sustainability considerations must be included in project decision-making frameworks. Overall, the answers to first two research questions have enabled us to determine that integrating sustainability as a factor in project selection can help in decision making to support the global requirement to improve the societal, environmental and economic impacts of project activities and their outcomes. Thus, it would be a logical argument to make here that considering sustainability as a factor in project decision-making can lead towards the selection of greener projects. These above have led us to formulate the successive **research question 3** i.e. *how can sustainability be balanced with other factors when all of these are collectively considered as PPS factors?* In order to answer the above research question the following objective was planned: Determine the relationship between sustainability and other IT project portfolio selection factors. This objective has been achieved by going through sub-objectives i.e. by first formulating sustainability evaluation criteria followed by the formulation of criteria to evaluate other project constraints and requirements such as project planning, threat and risks, financial analysis etc.

Sustainability evaluation criteria were needed to conduct a sustainability analysis of the proposed projects at the time of the formulation of projects proposals. These criteria are then used to feed into the project portfolio for decision-making. The selected case study organisation in this research was having multi-dimensional attributes towards environment, social and economic sustainability; and therefore, was a suitable case study to generate sustainability evaluation criteria. To achieve this, first identify sustainability related factors and then after the implementation an extensive practical assessment, generate sustainability evaluation criteria (details of this are presented in Chapter 4). These resultant criteria were used to practically perform sustainability analysis within project portfolio selection process for the identification and analysis of degree of presence or absence of the sustainably factors that are likely to impact, either positively or negatively. Overall, the resultant sustainability criteria sketch various questions to investigate the extent to which the project has considered economic, social and environment implications. Moreover, in these criteria some of the sustainability factors are related to the “acceptability” issues, which relate to the level and degree of acceptability of a project to the community, government etc.

In relation to the economic sustainability the criteria questions investigate the extent to which: (1) the proposed project is undoubtedly and unambiguously consistent with the National Priorities; (2) project benefits are greater than the costs or the project is expected to provide repeated future opportunities to the economy; (3) the people who are going to have access to the project facilities will equally belong to the 'rich', middle income' or 'poor' income classes; (4) the project’s expected benefits are not discriminated only towards ‘rich' or ‘middle' income class and 'poor' economic class will equally benefit from the project; (5) the clear community benefits from this project are in terms of increase of income or higher standard of living or higher productivity; (6) the project is realistically taking benefit from the development of all related previous projects; and (7) the project does not have any negative effect on GDP per capita and is not putting any negative effect on local economic opportunities for the community. Moreover, all of these questions were given specific weightages using the analytical processing technique, and these details are presented in Chapter 5.

In relation to the environment sustainability the criteria questions investigate the extent to which: (1) project proposal is aligned with the National/Government's Green IT Strategy; (2) the project uses existing organisational hardware resource/equipment; (3) measures have been considered on consuming less electricity, less paper, less consumable, less cooling and space requirements; (4) consolidations of infrastructure and related technologies have been considered or the use of centralized deployment architecture design has been considered; (5) end users have endorsed the project in terms of reduction of printing, promotion of paper free environment, increased digitization of document and increase of workflow automation (if relevant); (6) administrators have been consulted and agreement obtained on considering the environment aspects of the technology components e.g. raw material usage and emissions (air, water, land) and any other environmental impacts (global warming, ozone depletion, acidification, human toxicity, eco-toxicity, summer smog, eutrophication); and (7) it has been confirmed that the project does not have any adverse effect on the arable permanent cropland area (land capable of being ploughed and used to grow crops), or if it has then environmental considerations and effects of the project have been properly documented and communicated to the department.

In relation to the social sustainability the criteria questions investigate the extent to which: (a) a large proportion of the community will have access to the project facilities and/or will benefit from it; (2) the proposed project is consistent with provincial, sectorial and national environmental priorities; (3) related community has been consulted and they do consider this project as beneficial and acceptable in terms of both process and product; (4) the project does not disadvantage or discriminate any particular group in the related community; and in this regard, local elected representatives and community leaders have been consulted; (5) related project implementation agencies have been consulted and an agreement is obtained; (6) the project passes the health and safety (employees, contractors, customers, citizens) criteria without any doubt and/or requirement of more information; (7) The project will be maintaining human rights standards; and has it been confirmed that there are no risks of child labour in this project, or if there are risks of child labour then proper measures been taken to contribute to the elimination of child labour.

In order to made sure that any current or future proposed projects must provide all information related to the sustainability criteria, the above questions were included into the template of Project Initiation Document (PID). This has not only saved a considerable time of portfolio and project managers at the time of portfolio evaluation. However, it has been witnessed that it may not be possible to accurately answer all of the sustainability related questions at the time of project proposal, which were resolved by conducting group discussion sessions with the relevant project managers.

6.4 Criteria to Evaluate Project Planning, Threat and Risks, and Financial Analysis

Further towards achieving the third research objective and answering research question 3 i.e. after the formulation of sustainability evaluation criteria, extensive work was carried out to formulate criteria to evaluate other related portfolio selection factors. These include various operational constraints and requirements related to project planning, threat and risks, and financial analysis. The investigation of project

planning was concerned to investigate the extent to which the project is well planned. The resultant formulated criteria included question for assessing project's technical planning, resource requirements, planning to measure progress, duration, milestones timelines, criticality for delivery of future corporate services and completion. The investigation of threats and risks was concerned to investigate the extent to which the project has measured the threats and/or risks that are expected to occur during the implementation of the project and their mitigation strategy. The resultant formulated criteria included question for assessing staff ability to manage the proposed project as well assessing risks and mitigation planning related to financial investments, management, organisational cultural, delivery and implementation. The investigation of financial analysis was concerned to investigate the extent to which the project has reliable financial analysis. The resultant formulated criteria included question for assessing rationalisation of financial estimated budget, budget relevance to organisational initiatives. Moreover, the criteria also include assessment of the breakdown of project development and operational costs, and overall design of project in terms of its justifiably maximizing its lifespan with a least level of cost for care and maintenance.

Similar to the criteria for sustainability evaluation, all of the criteria for other factors were also made part of the PID by the case study organisation; so that any current or future proposed projects must provide all required information. Such practices can save a considerable time of portfolio and project managers at the time of portfolio evaluation.

6.5 Template for the Project Initiation Document (PID) for Projects' Proposals Data Collection and Portfolio Evaluation

To perform the practical application of this research several projects' data was required to be collected. While answering the third question, a strong need to develop a new template for the PID for Projects' proposals data collection and evaluation was felt. The existing template used by the case study organisation as well as the ones found during literature review, were collecting extremely limited information about the project. For example, the existing PID template of case study organisation included space for providing descriptive information on project description, project priority (i.e. low, medium, high), strategic initiative, financial need, responsible management and expected project length and risk (low, medium, high). All of these fields were descriptive and not at all appropriate to conduct detailed investigation especially in terms of sustainability evaluation. In order to develop a new PID template, i.e. as per the project portfolio selection criteria developed in this research, various in-house focused group sessions were conducted with the project and portfolio managers as well as with the top management. These efforts resulted in proposing a completely new template for PID, which was suitable to collect data for this research (presented in the Chapter 4). However, for the already running projects where such data was not already available, focused group sessions were conducted with the respected project managers to fill-in the missing or unclear data. These sessions also ensured confirmations on the reliability and completeness of collected projects' data for this research. Overall, based on the new PID template 10 mega IT projects' data were collected and all details of these along with the summaries of collected data are presented in the Chapter 5 and in Appendices. This generated new PID template can also be easily customised and used by other organisations.

6.6 The Use of Analytic Hierarchy Process (AHP) Technique of Multi Criteria Decision Making (MCDM)

As it was concluded in Chapter 2, the existing literature endorses the importance of adding sustainability as a factor in project portfolio selection for decision-making by the organisations. This does not mean that various other factors (as listed in Chapter 4) became less important, sustainability could be considered as an integral part of project portfolio. In return, considering sustainability as the main optimisation factor of project portfolio selection can help to achieve a sustainable society. In this regard the answer to research question 3 (as summarised above), provided us detailed criteria to evaluate sustainability and other factors in a PPS. This requirement of considering different PPS factors for portfolio optimisation led us to formulate the **research question 4**, which was: *how can sustainability be included in a project portfolio selection framework as the central optimisation factor for the selection of IT projects?* And in order to answer the above research question the following objective was planned: *Determine the relationship between sustainability with other project portfolio selection factors by taking sustainability as the main optimisation factor.* In order to achieve this objective a most suitable method to evaluate projects portfolio based on a number of criterions with related weightages was found and it was concluded that Multi-Criteria Decision Analysis / Making is as a valuable tool/method. This can be applied to many complex decisions as considered in this research.

Multi-Criteria Decision Making (MCDM) is best suited for this research to develop a characterization as a choice among portfolio projects. It helped us to focus in a logical and consistent way. Overall in this research, the MCDM method is used for group decision-making and to provide ability to portfolio managers to consider and talk about complex trade-offs among projects. Consequently, MCDM helped the decision makers at the case study organization to think, query the data, adjust the weightages, balance the portfolio and decide, and they could go through various cycles before they finally decide. In terms of classification, this research was considering *multiple-criteria evaluation problems,* where problems or projects consist of a predetermined number of alternatives, unambiguously known in the beginning of the process. In the application of MCDM, performance and/or score and/or rank in multiple criteria represent each alternative. The Analytic hierarchy process (AHP) is the most widely used method for the application of *Multiple-criteria evaluation problems* / MCDM (as discussed in Chapter 4), which has been applied in the practical evaluation of this research. In this research, the AHP technique helped portfolio decision makers find project(s) that best suit their goals. It provided a comprehensive and rational framework for structuring a portfolio decision problem, for representing and quantifying its elements, and for evaluating alternative projects. Using AHP process, this research enabled decomposing the decision-making problem into a hierarchy of criteria and alternatives. It is important to note here that a number of scenarios were developed consisting of distinctive hierarchies of criteria, which are presented in the Chapter 5 of this thesis and summarised in the next sections.

In this research, the selection of AHP technique for project portfolio selected has been most effective for a number of reasons. As it provided: (1) the choice of selecting one or more top project(s) from a portfolio, (2) a mechanism to ordered / sort portfolio projects from most to least desirable depending on the criteria in defined

in scenarios; (3) relative prioritisation of projects; (4) portfolio balancing mechanisms for settling arguments between portfolio managers using priorities definitions.

6.7 Investigation, Development and Implementation of Project Portfolio Selection Scenarios with Criteria Distributions

After working closely with portfolio managers and policy makers, this research resulted in the definition of project portfolio selection evaluation criteria's priorities based on the different levels of portfolio balancing needs. Overall, thirteen distinctive scenarios of evaluation criteria's priorities specifications were defined, where each of the scenario enabled decomposition of the decision-making problem into a hierarchy of criteria. Although, these scenarios considered to be sufficient by the cases study organisation, the number of *scenarios* may be increased or decreased depending on individual organisational needs. The choice of scenarios presented in this dissertation are sufficiently covering all aspects of this research, which were finalised after working with the case study organisation's portfolio managers and policy makers. The details of pairwise comparisons in these scenarios are specified in Chapter 5 and the hierarchy of criteria, are summarised in the following sections. By working with the case study organisation five different levels of priorities, i.e. in terms of hierarchy / pair wise comparisons, were specified i.e. the "extremely most important" is the highest required criteria priority, followed by "most important", "medium important", "less important" and "extremely less Important" is the lowest level of priority.

Scenario 1. In the scenario 1, sustainability wasn't considered as the main priority. This was primarily done to first see the outcome of projects selection under normal circumstances. Therefore, in scenario 1 finances and risks were considered as top priority. The project completion and planning were considered next, followed by the factors related to criticality of project, technical complexity in development, its need for operational continuity and improve efficiency. The sustainability related factors were given less priority but kept above the project commercial value, which was given the least priority. In some organisations, and especially the private sector organisations, project commercial value could be one of the most important priorities. The case study organisation of this research was a very large public/government organisation; and for them, commercial value is never that important. However, such situations were dealt in other scenarios.

Scenario 2. Here, the importance was given to project success and planning and were taken as top most criteria. This is because sometime in a portfolio, portfolio managers look for the project success and completion as the most important factors. This is especially done when all the projects are equally important and organisational funding is limited. However, there could be other reasons for doing this e.g. such as timely and successful delivery of government services etc. Other factors, such as related to finances and risks were considered as most important, followed by factors related to project criticality, operational continuity, need for organisational efficiency improvement and complexity. This is to be noted here that in this second scenario again sustainability wasn't considered as the main factor. This was again primarily done to see the outcome of projects selection under normal

circumstances where project success and completing are extremely important in comparison with sustainability. Consequently, in this scenario sustainability related factors were given the priorities as less important, and the least priority was again given to the project commercial value.

Scenario 3. Here, it was decided to consider operational continuity as the main factor, as well as the aspects of project criticality, its need for efficiency improvement and project complexity. This was done to deal with the argument of portfolio managers that: while considering operational continuity they don't usually want to end up selecting those project that are extremely complex and the preference should always be given to project which are comparatively less complex. In this scenario again sustainability wasn't considered as an important factor for the similar reasons explained above. Similarly, the project commercial value kept its position as per the previous scenarios. Moreover, factors related to finances and risks were considered here as second most important factors, and project completion and planning as medium important.

Scenario 4. This scenario was the first implementation of considering Sustainability as a main critical factor. Hence, in this scenario all sustainability related criteria were given the priorities as extremely most important. In order to observe the impact of this scenario with previous scenario, criteria related to project finances and risks were considered as second most important factors, followed by project completion and planning. The rest of the factors were given less importance other then project commercial value, which was given the very least priority to ensure that it has minimum impact on the project selections.

Scenario 5. This scenario as specifically defined for cases, and especially for the private sector organisations, where project commercial value could be one of the most important priorities. Therefore, in complete contrast to the previous case studied, here project commercial value was been given the top priority. In this scenario, sustainability was still considered as a factor, but to ensure it had minimal influence on the selection, all sustainability related factors were defined as extremely less important. The rest of the criteria have been kept like the previous scenario so that the impact of giving highest priority to project commercial value in comparison with sustainability could be observed and/or considered by the portfolio manager.

Scenario 6. This scenario provided another distinctive view of criteria priorities. In contradiction with above scenarios, here project finances and risks were considered as completely insignificant. Whereas, project completion and project planning related criteria were considered as the top key factors to support the decisions where crucial projects should be supported. Thus, the factors related to project criticality, need in terms of operational continuity and efficiency improvement with project complexity evaluation were also defined as most important. Another important priority decision in this scenario was to keep

sustainability related factors at neutral priority and project commercial value as less important.

Scenario 7. In this scenario the factors related to an organisation's operational continuity were given the top priority along with the sustainability as the second highest priority. Moreover, while selecting operational continuity as the main factor, the portfolio managers also selected project criticality, organisational efficiency improvement and project technical complexity considerations as equally important. Another important change in this scenario was giving neutral place to project commercial value to minimise its effect on the portfolio selection. Further, in order to deal with rare situations financial and project threats were taken as less important along with the project completion and planning as the least important factors.

Scenario 8. After scenario four, here again sustainability was considered as the main priority to observe its impact as compared to the previous three scenarios. However, in contrast with scenario 4 where sustainability as also considered as top priority, here project commercial value was placed at second highest priority. Further, in order to level the impact other factors with previous scenario and also to deal with situations where project finances and risks are not as important as sustainability, in this scenario all these factors were defined as medium important and rest of the factors were given less or least importance.

Scenario 9. This was another interesting scenario definition, where project commercial value was bundled with sustainability. It has been considered that sometimes organisations are obliged to give project commercial value as the main priority in a portfolio while also giving a high consideration to sustainability. Therefore, in this scenario these both aspects were defined as top priority. Moreover, the factors related to organisation operations and project complexly were neutralised by keeping them medium important. Furthermore, while combining sustainability factors with project commercial value as high priorities, all other factors were consequently given least priorities other then project completion and planning that were defined as less important.

Scenario 10. After defining all the above another scenario was needed where all of the factors are given equal importance. This was necessary to not only see the outcome of such portfolio, but to also compare the outcomes with all the above scenarios. Therefore, in this scenario all factors were given equal importance. Moreover, other organisations may edit this scenario and remove one of more factors, which they feel are not required for their portfolio. In this way, they will be able to customize the portfolio according to their preferences.

Scenario 11. This scenario permitted to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Moreover, to keep the influence of other sustainability factors as minimum, other sustainability factors are given the least priority in a portfolio of projects.

Scenario 12. This scenario permitted to priorities those projects that have positive societal implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. When in a portfolio Social sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor is given the least priority in this portfolio of projects.

Scenario 13. This scenario was defined to specifically support environmental sustainability. Here, environmental sustainability was selected as the main optimisation factor by giving it highest priority and all other where given the least priority in a portfolio of projects.

The above scenarios definitions enabled to answer the forth research question that was: how can sustainability be included in a project portfolio selection framework as the central optimisation factor for the selection of IT projects? However, in the first 10 scenarios individual sustainability factors were not considered separately. Therefore, in order to provide further detailed sustainability related portfolio decision making, the scenarios 11, 12 and 13 were defined, developed and implemented. These case studied enabled us to perform further sustainability analysis within project portfolio selection for the identification and analysis of degree of presence or absence of individual sustainably factors that likely to impact, either positively or negatively.

6.8 Project Portfolio Selection Policies

As detailed in Chapter 5 and presented in Appendices, once all the projects data in a portfolio have been evaluated using the above defined individual scenarios, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects. This was achieved by formulating various project selection policies, which incorporated organisational constraints, requirements and sustainability strategy. This has enabled us to answer the last **research question 5** of this thesis i.e. *how to determine sustainable portfolio policy for IT projects selection, which integrates both organisational strategic objectives and sustainability strategy?* These portfolio-balancing policies helped portfolio managers in achieving a portfolio that met both the objectives of the organisation optimally. In order to deeply and practically evaluate the outcomes of this research, two phases of practical evaluation were conducted. In each of the practical evaluation phase, sets of projects were considered for evaluation and portfolio balancing. In the phase 1, seven alternatives / projects were evaluated. In the phase 2, again seven projects were implemented by removing the top three scoring projects from phase 1 and three new projects were added. In this regard, all relevant evaluation information of the projects and their data collection is presented in Chapter 5 and in Appendices. In terms of scenarios implementations, all of the above-summarised 13 scenarios were implemented in both of the phases 1 and 2. The following section summarise the findings and related conclusions.

6.8.1 The Sustainable Project Portfolio Balancing Policy 1

In this research after closely working with the case study organisation's portfolio manages and policy makers, evaluation criteria's priorities are defined based on the different levels of portfolio balancing needs. The first part or the pre-requisite of Policy 1 stated, "define the portfolio evaluation criteria priorities based on the portfolio balancing requirement". This was initially resulted in obtaining criteria

specifications for ten scenarios with priorities (as discussed in the Chapter 5). They were found sufficiently covering all aspects of this research after working with the case study organisation's portfolio manages and policy makers. However, the number of *scenarios* can be increased or decreased depending on individual organisational needs. These specifications then enabled the feeding of all projects (alternatives) portfolio data (presented in Chapter 5 and in Appendices) into the system for AHP evaluation. The second part of Policy 1 stated: "for all of the scenarios, obtain and process all projects portfolio data as per the defined portfolio evaluation criteria". As a result of the application of Policy 1, this was achieved: (a) the projects portfolio evaluation criteria specifications as ten different scenarios having distinctive priorities; and (2) resultant individual projects' scores based on the AHP calculations. This outcome is then used for various judgments on individual scenarios as well as for the execution and evaluation of all remaining policies, which have been discussed in Chapter 5 and summarised in the next sections.

6.9 The Sustainable Project Portfolio Balancing Policy 2

The Policy 2 stated, "Gather the scores of top three ranked projects in all of the *scenarios* and then select the resultant top scoring projects". This policy allowed selecting the best three projects from all of the scenarios. First the top three scoring project in each of the scenario was taken and then combined the scores obtained by individual projects. It is important to note here that if a project was not in the top three scoring projects for a particular scenario, then its score is considered as zero. This was because only the top 3 scoring projects were selected from each scenario. However, portfolio managers depending on the number of projects in portfolio can relax this constraint. The main advantage of this policy is that it gives equal weightage to all of the scenarios. As a result, the portfolio managers are free to choose any number of top resultant projects. However, the case study origination in this research preferred to select between one to three top projects using this policy.

6.10 The Sustainable Project Portfolio Balancing Policy 3

The Policy 3 allowed the calculation of *Median* and *Mode* of rankings for individual project in all scenarios as well as the calculation of *Mean* scores. It stated "*calculate the Median and Mode of rankings for individual projects and the Mean of project scores in all scenarios*". This policy gave flexibility to the decision makers to base their portfolio selection decision either of the *Median* or *Mode* of the rankings for individual projects in all scenarios. Scenario implementation showed that same projects got selected for both of the *Median* and *Mode* calculations. However in the practical investigation, calculating *Median* was appropriate as compared to the *Mode*. This is because for dissimilar ranked values of all projects, *Mode* cannot be calculated. Moreover, the *Mean* of individual project scores in all scenarios were also calculated to provide a conflict resolution mechanism when two projects score the similar *Median* or *Mode* value. Overall, this policy provided individual as well as combined mechanisms for project selection, where the *Mean* of projects scores can be considered for further deep analysis and decision-making.

6.11 The Sustainable Project Portfolio Balancing Policy 4

This policy gave further flexibility to the decision makers to base their portfolio selection decision by first prioritising the scenario itself and then calculating the *Mean*, *Median* or *Mode* of individual projects. This has proved to be very useful when

the portfolio decision makers perceive one or more scenarios as an organisational priority. With respect to policy 3, this Policy 4 allowed incorporation of further priorities to individual scenarios. So, in addition to the calculation of *Mean, Median* and *Mode* of individual project rankings in all scenarios, the policy 4 allows prioritising the score of each scenario. For example, if a project had scored 0.4 initially in scenario one, it could be prioritised at 0.8 if its propriety is defined as 2 i.e. 0.4 * 2 = 0.8. Moreover, if the portfolio manager would like to exclude a scenario from the portfolio, then they can define its priority as 0, the default priority is 1. Moreover, the effect of defining priority on projects rankings is practically evaluated. For example, if a project was ranked at number 6 initially in a scenario one, it could be ranked at 2 if its propriety is defined as 3 i.e. 6/3 = 2. It is important to note here that in the case of prioritising score it needs to be multiplied with the priority value and in the case of *Mode* it needs to be divided with the priority value. There is no limit on defining a priority and any number can be specified. The spreadsheet tool developed in this research automatically performs the calculations. After detailed analysis it was observed that defining priority to ranks was not an ideal solution. This was mainly because it was not considering the actual scores of projects; and thus, couldn't tell how closely two or more projects were scoring in a portfolio after priority definitions. However, defining priority to scores gave useful outcomes in terms of *Median* and *Mean* calculations. The outcomes proved that it was not possible to calculate *Mode* of score values. This was because mostly the projects scores consist of distinct values and they remain distinct even after applying priority. This has further proved previously established conclusion in policy 3 that calculating *Mode* for project rankings is not a reliable solution. Here, another finding was made that calculating *Mode* for project scores is also not a workable solution due to non-applicability of *Mode* calculations. In relation to *Median*, no major effect on the portfolio before and after the application of *Median* was noted especially when only one of the scenarios was prioritised, detailed justification of these findings are provided in Chapter 5. Thus, it is concluded that for policy 4 when defining priorities to individual scenarios, taking *Mean* of prioritised scores is the most suitable calculation.

6.12 The Sustainable Project Portfolio Balancing Policies 5, 6 and 7

As stated above, the case study organisation in this research was having multi-dimensional attributes towards environment, social and economic sustainability. In order to provide sustainability related portfolio decision making, a rigorous sustainability analysis was needed both at the time of project proposal formulation and project portfolio evaluation. The above four policies enabled the portfolio managers to consider sustainability in a project portfolio selection as the central optimisation factor for the selection of IT projects. However, in the first 10 scenarios and consequently in policies 1-4 individual sustainability factors were not considered separately. Therefore, in order to provide further detailed sustainability related portfolio decision making, the scenarios 11, 12 and 13 were defined, developed and implemented. These cases studied enabled performing further sustainability analysis within project portfolio selection.

The policy 5 stated: *"select the top three projects by considering Economic sustainability as the main optimisation factor".* When in a portfolio Economic sustainability is selected as the main optimisation factor then it is given the highest

priority against every other factor. This policy allowed to priorities those projects that have positive economic implications or their negative impacts on wider economy are either avoided or mitigated during the life of the project. Similarly, the policy 6 stated: *"select the top three projects by considering Social sustainability as the main optimisation factor".* When in a portfolio Social sustainability is selected as the main optimisation factor then it is given the highest priority against every other factor. This policy allowed to priorities those projects that have positive societal implications or their negative impacts on social stability are either avoided or mitigated during the life of the project. A practical application of this policy showed that although projects have scored slightly differently when *social* and *economic* sustainability factors were interchangeably considered on higher priority, sometimes the top projects remained in a similar sequence. However, the results were quite different when Environment Sustainability is considered as main factor. The policy 7 was developed to select projects based on the *Environmental* sustainability. The policy 7 stated: *"select the top three projects by considering Environmental sustainability as the main optimisation factor".* This policy allowed to priorities those projects that have positive *environmental* implications or their negative impacts on *environment* are either avoided or mitigated during the life of the project. In the practical evaluations, it was observed that projects scoring poor in terms of Environmental sustainability most of the times also scored poor for Economic and Social sustainability, and vice versa. Although, there is no direct relationship between the two, it is observed that in some projects the negative *Environmental* impacts may yield benefits at a reduced rate depending on the extent of environmental costs, such negative impacts may in fact contribute to the net losses to the economy. Therefore, in order to see a combined effect of Economic, Social and Environmental sustainability on a portfolio of projects Policy 8 was developed and implemented.

6.13 The Sustainable Project Portfolio Balancing Policy 8

In order to observe a combined effect of *Economic, Social* and *Environmental* sustainability factors on a portfolio of projects Policy 8 is implemented. The Policy 8 stats that "calculate the *Mean, Median* and *Mode* of individual project rankings and *Mean* of project score in three scenarios where in each of them *Economic, Social* and *Environmental* sustainability was considered as the main optimisation factor, respectively". In this policy three scenarios are considered. Results showed that once again *Not Applicability* problems occurred with Mode calculation when all projects had distinct values. According to the definition of Mode, the "Mode" is the value that occurs most often. If no number is repeated, then there is no Mode for the list. Therefore, this outcome that Mode is not useful to prioritise projects in a portfolio. When comparing outcomes of Rank *Mean* with *Rank Median,* it has been observed that both *Rank Mean* and *Rank Median* provided same results, which also matched to the outcomes produced by taking the *Mean* of scores. However, in such calculations if two (or more) projects score the same result then in is necessary to look at various outcomes using *Mean* and *Median* calculations of *Ranks* and *Mean* of scores to determine the most viable alternative. Moreover, in such situations the portfolio managers must consult strategic alignment of projects as a conflict resolution mechanism. Overall, the implementation of policy 8 allowed the calculation of *Mean, Median* and *Mode* of rankings as well as *Mean* of projects scores for individual projects in three scenarios. This gave options to the decision makers to base their portfolio selection decision on either of the calculation method excluding *Mode* calculations.

In the extended implementation policy 8, a mechanism of *priority* definitions was included to automatically calculate the impact of defining priority on rankings and scores. It was already established in policy 4, that defining priority to ranks is not an ideal solution. This was mainly because it was not considering the actual scores of projects; and thus, couldn't tell how closely two or more projects were scoring in a portfolio after priority definitions. This finding was again confirmed in this policy. In terms of the implementation of priority scores, the policy 8 also allowed prioritising the scores. This extension was very useful especially when the portfolio decision makers perceived one or more scenarios as an organisational priority. In terms of calculations, the implementation of policy 8 in both phase 1 and 2 proved that calculating *Mean* was suitable as compared to the *Median* and *Mode*. This was because changing priority of only one scenario doesn't always effect *Median* and *Mode* outcomes; especially if the project was already scoring low or high, the the middle scoring project would still appear as favourite in the resultant portfolio. Moreover, for distinct ranked values of projects, *Mode* cannot be calculated as already concluded above in policy 3 and 4.

6.14 The Preferred Project Portfolio Balancing Policies

Although all of the project portfolio balancing policies 1-8 were able to support the decision makers in choosing the best projects in a portfolio, the policies 3, 4 and 8 were considered to be the most useful by the case study organisation. This is mainly because the portfolio decision makers were usually seeing one or more scenarios as an organisational priority in comparison to the others, and the policy 3 and 4 provided a combined view of various scenarios as well as policy 4 allowed prioritising the ranking of each scenario. Thus, the decision makers had flexibility to base their portfolio selection decision by first prioritising the individual scenarios and then calculating the individual project ranking and /or scores in all scenarios. Same was the case for policy 8 which gave flexibility to the decision makers to base their portfolio selection decision by first giving different priorities to *economic*, *social* and *environmental* sustainability as the main optimisation factors, and then looking at the outcomes of individual projects.

Chapter 7: Conclusions / Future Work

In this Chapter, conclusions are summarised and an outline future research directions is presented.

7.1 Research Conclusions

This research aimed to develop a sustainable PPS framework for the selection of IT projects, which is determined by corporate strategy plan and by considering sustainability as the main PPS optimisation factor along with balancing it with other PPS factors. In this section the summarised conclusions in relation to the research objective are presented.

1. This research resulted in proposing a Sustainable Project Portfolio Selection Process for the IT Projects namely "SPPS-IT". The implemented SPPS-IT process helped the portfolio managers to select project portfolios that maximised the criteria of interest of the organisation i.e. in line with their strategies, and which is also suitably balanced on both quantitative and qualitative parameters they chose. The research outcomes also provided the means to balance the portfolio using 8 different portfolio-balancing policies to select the most optimum portfolio as per of interest of the organisation.
2. In Chapter 2, it was concluded that there is an existence of abstract-level conceptual ideas on decision-making frameworks for sustainability. However, to best of our knowledge limited literature was found describing how sustainability can be considered in a project portfolio selection evaluation stage which selecting IT projects. The following are the summary of findings of the literature survey.
    a. In relation to the implementation of sustainability strategy in an organisation (e.g. the case study organisation), it has been concluded that for the top management and/or business leaders of an organisations, it is important to have a clear and comprehensive sustainability strategy incorporated into organisational corporate-level strategy.
    b. It has been evident via the literature survey as well as in the implementation phase that taking a balanced approach to sustainability has grater advantages and each part of the balanced sustainable development often supports each other.
    c. The literature survey also concludes that Green and Sustainable IT initiatives need to bring various cost savings opportunities. One of the means to achieve this is by prioritisation of projects.
    d. The literature review on existing project portfolio management lifecycle models shows that only the "pre-project/initiation" phase is concerned with project(s) selection, where ideas are formulated and the business reviews are done.

3. The proposed SPPS-IT process proved to be helpful in selecting a project portfolio that maximises the criteria of interest to the selected case study organisation i.e. in line with the cooperate strategy and sustainability strategy, and which was also suitably balanced on both quantitative and qualitative parameters they preferred.

4. The overall SPPS-IT process has been divided into various distinct pre-processing, data/information flow, main stages, post-processing and document stores. The pre-processing stages of SPPS-IT included economic, environment and social factors, which resulted in the specification of sustainability constraints and generation of sustainability criteria. Once the initial pre-screaming and specification of proposals were completed, the SPPS-IT, performed detailed (actual) *evaluation of projects proposals.* Using these *evaluation* constraints interactions among the various projects were measured, including interdependencies, division of resources, planning etc. The main constraints that have been evaluated included *criticality*, *project success*, *benefits*, *strategic improvement, efficiency improvement, risks, operational continuity, financial value, commercial value*, and *technical complexity* of the portfolio projects. Finally, when all the projects in a portfolio have been evaluated, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects using different portfolio-balancing policies.

5. These portfolio-balancing policies helped portfolio managers in achieving a portfolio that met both the strategic and sustainability objectives of the organisation optimally. Therefore, while applying a portfolio-balancing policy all relevant evaluation information of the projects and evaluation factors scoring /ranking must be made available to allow decision makers to evaluate the portfolio and make informed decisions.

6. In some of the cases the users may omit a stage if that process was already completed to simplify and expedite the project portfolio selection process.

7. Sustainability considerations must be included in project decision-making frameworks. Sustainability evaluation criteria were needed to conduct a sustainability analysis of the proposed projects at the time of the formulation of projects proposals. These criteria are then used to feed into the project portfolio for decision-making.

8. The selected case study organisation in this research was having multi-dimensional attributes towards environment, social and economic sustainability. Who first identified sustainability related factors and then after the implementation an extensive practical assessment, sustainability evaluation criteria was generated. Overall, the resultant sustainability criteria sketch various questions to investigate the extent to which the project has considered economic, social and environment implications. Moreover, in these criteria some of the sustainability factors are related to the “acceptability” issues, which relate to the level and degree of acceptability of a project to the community, government etc.

9. The sustainability evaluation and all of the criteria for other factors were made part of the PID by the case study organisation; so that any current or future proposed projects must provide all required information. Such practices can

save a considerable time of portfolio and project managers at the time of portfolio evaluation.

10. Multi-Criteria Decision Making (MCDM) is best suited for this research to develop a characterization as a choice among portfolio projects. It helped us to focus in a logical and consistent way. Overall in this research, the MCDM method is used for group decision-making and to provide ability to portfolio managers to consider and talk about complex trade-offs among projects. Consequently, MCDM helped the decision makers at the case study organization to think, query the data, adjust the weightages, balance the portfolio and decide, and they could go through various cycles before they finally decide.
11. The selection of AHP technique for project portfolio selected has been most effective for a number of reasons. As it provided: (1) the choice of selecting one or more top project(s) from a portfolio, (2) a mechanism to ordered / sort portfolio projects from most to least desirable depending on the criteria in defined in scenarios; (3) relative prioritisation of projects; (4) portfolio balancing mechanisms for settling arguments between portfolio managers using priorities definitions.
12. Overall, thirteen distinctive scenarios of evaluation criteria's priorities specifications were defined, where each of the scenario enabled decomposition of the decision-making problem into a hierarchy of criteria. Although, these scenarios considered being sufficient by the cases study organisation, the number of *scenarios* may be increased or decreased depending on individual organisational needs. The choice of scenarios presented in this dissertation are sufficiently covering all aspects of this research, which were finalised after working with the case study organisation's portfolio managers and policy makers.
13. Once all the projects data in a portfolio have been evaluated using the individual scenarios, the SPPS-IT provided various mechanisms to achieve a balanced portfolio of projects. This was achieved by formulating eight project selection policies, which incorporated organisational constraints, requirements and sustainability strategy. Although all of the project portfolio balancing policies 1-8 were able to support the decision makers in choosing the best projects in a portfolio, the policies 3, 4 and 8 were considered to be the most useful by the case study organisation. This is mainly because the portfolio decision makers were usually seeing one or more scenarios as an organisational priority in comparison to the others, and the policy 3 and 4 provided a combined view of various scenarios as well as policy 4 allowed prioritising the ranking of each scenario.

In the following sections research limitations and possible future research directions are outlined.

7.2 Research Limitations and Future Work

This research resulted in proposing a sustainable project portfolio selection process for IT projects; and therefore, the major focus of this research was towards IT projects selection. In the future, this framework can be implemented for other types of projects selections. Such an implementation will not require massive changes in the SPPS process. However, in this research the relationship between sustainability and

other IT project portfolio selection factors were determined. This was done by first formulating sustainability evaluation criteria followed by the formulation of criteria to evaluate other project constraints and requirements such as project planning, threat and risks, financial analysis etc. If this framework is to be applied in other non-IT domains then this evaluation criteria may need to be customised as per the projects types / domain of application.

In order to perform the practical application of this research several projects' data was collected. The existing template used by the case study organisation was collecting extremely limited information about the proposed projects. To enable the collection of required data, a new paper–based template of the PID for Projects' proposals data collection and evaluation was developed. In order to develop this new PID template, i.e. as per the project portfolio selection criteria developed in this research, various in-house focused group sessions were conducted with the project and portfolio managers as well as with the top management. These efforts resulted in proposing a completely new template for PID, which was suitable to collect data for this research. One limitation or possible future work of this research is the implementation of digital PID / data collection forms to replace the paper-based form. This will massively reduce the project portfolio selection time during portfolio evaluation process. Moreover, while implementing this in other organisations the new data collection forms may also need to be customised based on the evaluation criteria or projects types / application domain.

The empirical evaluation of this research has been based on defining several portfolios of projects with varying portfolio evaluation criteria priorities. In this regard, this research enabled the definition of portfolio evaluation criteria and sub-criteria. The overall portfolio evaluation criteria used in this research have been defined after going through the literature and by working with the case study organisation's portfolio managers and policy makers. Overall 12 levels of portfolio evaluation criteria was defined that included financial analysis, protection from threats and risks, completion (success), planning, criticality, operational continuity, efficiency improvement, technical complexity (fitness), economic sustainability, social sustainability, environment sustainability and project commercial value where each of these also included a number of sub-criterions, where applicable. Once these criteria have been defined, the case study organisation also described various scenarios with varying levels of criteria priorities. In this regard, "extremely most important" was defined as the highest required level, followed by "most important", "medium important", "less important" and "extremely less important" was the lowest level of priority. Using these five levels of criteria priorities and twelve levels of portfolio evaluation criteria, thirteen distinctive scenarios of portfolio evaluation criteria's specifications were defined. Here, each of these defined scenarios enabled decomposition of the project portfolio selection decision-making problem into a hierarchy of criteria. All of these thirteen scenarios were formulated in focused group sessions by closely working with portfolio and project managers in focused groups sessions. For the case study organisation, these thirteen scenarios have been found to be sufficiently covering all aspects of this research; however, the number of scenarios may be increased or decreased depending on individual organisational needs. Moreover, due the fact there could be hundreds of possible scenarios using five levels of criteria priority and twelve levels of portfolio evaluation criteria this process could be automated to come up with numerous possible scenarios. For example, in the future a software system may be developed which can automate this process of

scenario generation depending on organisational priorities. Moreover, future work can also be conducted to fully automate the sustainable project portfolio evaluation process. To achieve this a four-step automation will be required after the organisational projects evaluation goals have been identified i.e. (1) feeding of portfolio evaluation criteria; (2) definition of the weights / priorities for criterions (i.e. as per the optimisation factor); (3) selection of a sustainable portfolio policy to generate portfolio of projects; (4) evaluation of the portfolio of projects as per the defined criterions and weightages. After completing all these steps, the portfolio managers should assess the portfolio evaluation outcomes; and in case of unsatisfactory outcomes, the system should loop back to step-2 to enable the modification of criteria and weights for re-evaluation.

This research provided various measures to balance the projects selection portfolio using eight different portfolio-balancing policies to select the most optimum portfolio as per of interest of the organisation. These portfolio-balancing policies helped case study organisation's portfolio managers in achieving the outcomes that met the objectives of the organisation optimally. Moreover, two intensive phases of practical evaluation were conducted. When implementing these policies to other organisations, their portfolio decision makers may see one or more policies more suitable to their needs. In such circumstances, they may directly adapt policy 4 or 8 that provide a combined view of various scenarios as well as prioritisation of scores. Furthermore, although some work has been done for considering sustainability in the Portfolio Management and Program Management, the efforts around this are quite limited. In this regard, future work can also be extended towards building sustainable portfolio management and program management. Finally, in this research the implementations of AHP process and overall practical evaluation have been done using a mixture of automatic and manual methods, which was indeed very time consuming. It will be nice if a fully automated software can be develop for the implementation and execution of all of the AHP processes and portfolio-balancing policies.

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Appendices

Appendix 1: Projects Eveluation Data

Appendix 2: Detailed AHP Projects Evaluation Data