Department of Computing Sciences

A Business Intelligence Framework for Supporting Strategic Sustainability Information Management in Higher Education

By

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Declaration of Own Work

I, Ross Haupt, hereby declare that this dissertation for the degree Magister Commerce is my own work and that is has not previously been submitted for assessment or completion of any postgraduate qualification to another university or for any other qualification.

Ross Haupt

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Abstract

In the higher education sector, a number of Higher Education Institutions (HEIs) are playing a leading role in promoting sustainable initiatives. Effectively managing these initiatives however can be a complex task and requires data and information from multiple aspects of operations. In an HEI, operating sustainably means ensuring financial sustainability, social sustainability, environmental sustainability and educational sustainability. In order to manage sustainability effectively, HEIs require an integrated tool that can provide information on all areas of sustainability.

HEIs face a number of challenges in effectively managing sustainability information, such as siloed data and information, and poor sharing and communication of information. Business Intelligence (BI) can assist in overcoming many of the challenges faced by organisations in effectively managing strategic sustainability information. This study investigates both the constraints to effective sustainability information management and the challenges of BI. A BI framework to support effective strategic sustainability information management is proposed.

Nelson Mandela Metropolitan University (NMMU) is one such HEI, which is affected by the challenges of managing strategic sustainability information. NMMU is therefore used as a case study in this research. A BI solution, Sustainable BI, was developed based on the proposed framework. The main goal of sustainable BI is to provide strategic management at NMMU with a tool that can provide integrated sustainability information that can assist in overcoming the challenges in effectively managing strategic sustainability information.

Sustainable BI was evaluated by strategic management at NMMU who are responsible for managing sustainability at NMMU. The evaluation took place through a usability study. The study revealed to what extent Sustainable BI could effectively manage strategic sustainability information at NMMU. The BI framework was iteratively improved on based on the results of the evaluations. The contributions from this study are a model for sustainability management, a BI Framework to support strategic sustainability information management and a BI solution, Sustainable BI.

Keywords:

Sustainability, Higher Education, Business Intelligence, Performance Dashboards.

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Glossary

BA	Business Analytics
BI	Business Intelligence
BI&A	Business Intelligence and Analytics
BPM	Business Performance Management
CSF	Critical Success Factor
DHET	Department of Higher Education and Training
DSR	Design Science Research
DB	Database
DW	Data Warehouse
EMIS	Environmental Management Information System
ERP	Enterprise Resource Planning
ETL	Extract, Transform and Load
GRI	Global Reporting Initiative
HEI	Higher Education Institution
HEMIS	Higher Education Management Information System
ICT	Information and Communications Technology
IT	Information Technology
IS	Information Systems
KPI	Key Performance Indicator
NMMU	Nelson Mandela Metropolitan University
OLAP	Online Analytical Processing
RO	Research Objective
RQ	Research Question
SA	South Africa
SQL	Structured Query Language
SSAS	SQL Server Analysis Services
SSIS	SQL Server Integration Services
STARS	Sustainability Tracking, Assessment & Rating System
UI	User Interface
US	United States

Chapter 1. Introduction

1.1 Background

The concept of sustainability and corporate social responsibility has become increasingly more important in the last decade (Petrini and Pozzebon, 2009). The World Commission on the Environment and Development define sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet its own needs (United Nations, 1987). The triple bottom line is a concept used to show how an organisation is no longer only affected by monetary gain, but also by the impact of the organisation on society as a whole (Elkington, 2004). The three factors that make up the triple bottom line are environmental, social and economic, and these three factors encompass the entire spectrum of sustainability. In order for an organisation to be sustainable, it needs to excel in all three of these areas.

Higher Education Institutions (HEIs) are not immune to sustainability issues and have thus been affected by the increased awareness in environmental and social responsibilities (Disterheft, Ferreira da Silva Caeiro, Ramos and de Miranda Azeiteiro, 2012). HEIs have become increasingly interested in tracking and understanding both their environmental and social impacts in order to enhance the institution's long-term sustainability (Posner and Stuart, 2013). The increased competition in the higher education sector, brought about by an increase in the number of private institutions, has resulted in a need for faster and more accurate decision-making at all levels of the institution (Stocker, 2010). HEIs globally have begun to understand that effective sustainability information analysis can enable more effective sustainability management and can be used as a tool to not only measure sustainability efforts, but also to manage long-term risks and opportunities for the organisation (Posner and Stuart, 2013).

The majority of sustainability efforts in HEIs have, however, been confined to institutions in developed regions such as Europe, Asia, Australia, Canada and South America and HEIs in the developing countries of Africa are lagging behind. Two possible factors causing the slow penetration in developing countries which have been reported are the lack of data access and the lack of accurate information (Pina, 2011; Velazquez, Munguia and Sanchez, 2005). The new regulations for South African HEIs could help improve quality of sustainability data and

information since sustainability reporting is now mandatory for all public HEIs in South Africa (Department of Higher Education and Training, 2014).

The increased awareness in sustainability is highlighted by the number of sustainability reporting tools and frameworks being developed (Institute of Directors, 2009; Pina, 2011). These tools and frameworks provide organisations with guidelines on how to report on sustainability. Examples of these reporting frameworks include the Global Reporting Initiative (GRI), ISO 14000 series, the Triple Bottom Line and the Sustainability Tracking, Assessment and Rating System (STARS). The operations of HEIs differ from standard business enterprises, which causes many of the reporting tools and frameworks, including the GRI, ISO 14000 series, and the Triple Bottom Line to be insufficient for HEIs. STARS is a reporting framework developed specifically for HEIs in North America (Association for the Advancement of Sustainability in Higher Education, 2011). Many HEIs in South Africa have begun to realise the benefit of the STARS reporting framework (Pina, 2011). Nelson Mandela Metropolitan University (NMMU), which will be the focus of this study, is one of these HEIs. NMMU has adopted STARS as part of its sustainability reporting framework.

Organisations are turning to these dedicated sustainability reporting tools to assist them in complying with the complex sustainability reporting requirements. These tools are limited in their capabilities however and are not all suited to the requirements of HEIs. Many of the tools do not cover the entire sustainability spectrum, but focus only on environmental reporting and neglect the social aspects of sustainability, while others only focus on two of the three aspects and neglect the third. The reporting guidelines that these tools follow are also not adequate for HEIs, since the focus of most of these tools is reporting according to the GRI and GHG guidelines and not the STARS guidelines (KPMG, 2012).

The limited nature of these tools highlight the need for an alternative tool to assist organisations with improved and more effective management of their sustainability efforts. Strategic management requires more than just a reporting tool (Goni, Sahran, Mukhtar, Shukor and Chofreh, 2013). For strategic management to effectively manage sustainability, a tool is required that can effectively analyse data and provide management with the information required to make decisions. Advances in Information and Communications Technology (ICT) have improved the way in which management produces reports and makes decisions. Tools that easily enable the gathering, storing, processing and presenting of data are readily available.

One such tool is Business Intelligence (BI). Both Pina (2011) and Bosire (2014) highlight the key role that BI tools play in effectively managing sustainability in HEIs. The successful implementation of BI tools can ensure that management can simply access accurate and up-to-date information when desired. These tools can provide strategic management with a complete 360 degree view of the organisation, enable faster, more accurate and more reliable decisions (Adelman, Moss and Abai, 2005). The Gartner IT Glossary defines BI as an umbrella term that includes all different tools, applications, infrastructure and best practices that enable the access to and analysis of raw data and information to improve and optimise decisions and performance of an organisation (Gartner, 2014).

The growth in popularity of BI in a variety of organisations has been fuelled by the increasingly complicated decision-making process that has arisen due to exploding data volumes, a need for greater agility of decision-making, and technological progress leading to more sophisticated software tools that are being developed (Sabherwal and Becerra-Fernandez, 2011). The value provided by BI tools is heavily dependent on the underlying data. Up-to-date, real-time data provides a greater foundation for accurate decision-making than historical data in isolation (Watson, 2009). A BI solution that makes use of both historical data and real-time data can assist in reducing delays in the decision-making process, thereby increasing the value of the decision (Hackathorn, 2004). The use of traditional BI tools does not meet the requirements of strategic sustainability management, because the main focus of these tools is historical reporting and ad hoc queries. This falls under the domain of descriptive analytics, which is a retrospective analysis that provides insight into what is currently happening and what has already happened (Kandogan, 2012). This is not suitable at a strategic level where the focus is on long-term strategy and decision-making, which requires a more predictive approach (Hacklin and Wallnöfer, 2012).

Although the BI discipline originated in the standard business world, it is becoming an increasingly popular topic in higher education (Guster and Brown, 2012). The usage of BI software tools in South African HEIs is relatively unknown. However, it has been reported that South African HEIs use a variety of tools for information processing and reporting (Bosire, 2014). In particular, Enterprise Resource Planning (ERP) systems are commonly used, however these systems do not provide all the capabilities that BI tools provide. Because of the limited reporting capabilities of ERP systems, these tools do not adequately meet the reporting requirements of these institutions, particularly for strategic level reporting. This study

investigates possible approaches to assist HEIs to effectively manage strategic sustainability and it proposes a BI framework to assist in effectively managing strategic sustainability information. A number of existing frameworks exists in software engineering, and this is no different in the field of BI. Mnkandla (2009) states that a software framework should provide generic guidelines to the way that things should be done in a software implementation. The information age has brought about an exponential increase in the amount of data and information available to both individuals and organisations (Baltzan and Phillips, 2014). The diverse nature of sustainability means that data is often sourced from multiple data sources. Organisations are continually gathering, interpreting and synthesising information to enable more effective decision-making (Tushman and Nadler, 1978).

NMMU is used as the case study for this research and is a suitable case since sustainability is a core focus and strategic priority of the institution. The core vision of NMMU is to be a "*dynamic African university recognised for leadership in generating cutting-edge knowledge for a sustainable future*" (Nelson Mandela Metropolitan University, 2008, p. V). The NMMU mission is "*To offer a diverse range of quality educational opportunities that will make a critical and constructive contribution to regional, national and global sustainability*." Sustainability is a key focus across all institutional operations, including the core operations, the educational component of sustainability. NMMU also focusses on financial sustainability, social sustainability and environmental sustainability.

1.2 Relevance of Research

NMMU, like other HEIs, has been affected by the heightened awareness in sustainability, which has affected the manner of decision-making and reporting practices at the strategic level of the organisation. Decision-making at the strategic level of the organisation should consider all spheres of sustainability to ensure the long-term future of the institution.

The increased awareness in sustainability at NMMU is highlighted by the NMMU Vision 2020 strategic plan (Nelson Mandela Metropolitan University, 2008). Vision 2020 serves as a guideline as to what kind of a university NMMU would like to be by 2020. Sustainability is a key theme throughout the Vision 2020 strategic plan, which is highlighted by the development of a number of strategic priorities that will aim to secure the long-term sustainability of the organisation.

A large amount of data relating to the sustainability of the organisation is generated and recorded by NMMU, however the use of such data to manage sustainability at the strategic level is limited. The use of BI tools in the management of sustainability at a strategic level at HEIs in South Africa, and specifically at NMMU, is also limited (Bosire, 2014).

1.3 Problem Statement

HEIs are able to gather large amounts of data about a wide range of areas. Many of these institutions however, are inefficient in their data use, leading to substantial delays in analysing the data and finding patterns and trends (Siemens and Long, 2011).

NMMU is no different when it comes to the use of data. A number of goals relating to sustainability have been identified by NMMU in the NMMU Vision 2020 strategic plan. Although the data is available to monitor and manage many of these goals, there is currently a lack of proven techniques and methods to analyse the data to enable the support of strategic sustainability management.

The following research problem has been formulated:

> *There are currently limited recommendations and guidance for using BI in the management of strategic sustainability information in Higher Education Institutions (HEIs).*

1.4 Research Aim

The aim of the research is to:

Develop a business intelligence framework to support the effective and efficient management of strategic sustainability information in Higher Education Institutions (HEIs).

A proof of concept prototype will be developed to help determine to what extent BI can support sustainability information management. The prototype will be implemented based on the proposed BI framework.

1.5 Research Objectives

The main research objective (RO_M) of this study is:

> *To design a business intelligence framework that can be used to support strategic sustainability information management for Higher Education Institutions (HEIs).*

Several secondary research objectives have been identified, namely:

RO_1: Identify the drivers of sustainability in HEIs.

RO_2: Identify the constraints to effective sustainability management in HEIs.

RO_3: Identify the strategic sustainability indicators at NMMU.

RO_4: Identify the benefits and challenges of BI.

RO_5: Identify the factors that are critical to the success of a BI project.

RO_6: Identify the requirements of a BI solution to support effective strategic sustainability information management in HEIs.

RO_7: Identify how a BI solution to support strategic sustainability information management can be designed and evaluated.

RO_8: Determine, through evaluation, if the BI solution can support effective and efficient strategic sustainability information management.

1.6 Research Questions

The main research question (RQ_M) of this study is:

> *How can the management of strategic sustainability information in Higher education Institutions (HEIs) be made more effective and efficient using business intelligence?*

In the process of answering this question and, a number of secondary research questions will be solved. These secondary research questions are:

RQ_1: What are the drivers of sustainability in HEIs?

RQ_2: What are the constraints to effective sustainability management in HEIs?

RQ_3: What are the strategic sustainability indicators at NMMU?

RQ_4: What are the benefits and challenges of BI?

RQ_5: What are the critical success factors (CSFs) of a BI project?

RQ_6: What are the requirements of a BI solution to support effective strategic sustainability information management in HEIs?

RQ_7: How should a BI solution to support strategic sustainability information management solution be designed and evaluated?

RQ_8: To what extent can the implemented BI solution support effective and efficient strategic sustainability information management in HEIs?

1.7 Scope and Envisioned Contribution

A conceptual BI framework to support strategic sustainability information management will be designed. The study will focus specifically on South African HEIs, and more specifically NMMU, the case study for this research. A BI solution will be implemented based on the design of the framework. The BI solution will focus on limited aspects of sustainability as the time-constraints of this project limit the scope. The requirements of a BI solution to manage strategic sustainability information in higher education will be identified through a literature review and interviews with the relevant stakeholders at NMMU. The tool that will be used to implement the prototype will be dependent on licencing fees, as the budget of the project will dictate which tools can be used. Because the focus of this research is sustainability information management at the strategic level of the organisation, the BI solution to be implemented will focus specifically on the analysis of the information in the analytical layer, and the presentation of the information in the monitoring layer (Muntean, Sabau, Bologa, Surcel and Florea, 2013).

1.8 Research Methodology and Dissertation Structure

The Design Science Research (DSR) methodology will be the underlining research methodology that will be followed. The key requirement of DSR is the development of an artefact which aims to solve a relevant organisational problem that can lead to the implementation of the artefact in a real-world situation. DSR is motivated by the need to improve the existing environment by the development of new artefacts that will assist in the improvement of current methods and processes (Hevner, 2007). The BI framework that will be developed can be viewed as the artefact in this research (Hevner, March, Park and Ram, 2004), and therefore this methodology will be suitable for this study. The structure of this dissertation is based on the DSR methodology that will be followed in this study. A brief outline of the chapters contained in this dissertation is provided below. The structure of the dissertation is

illustrated in Figure 1-1. The DSR methodology will be discussed in greater detail in Chapter 2.

Chapter 2: Research Methodology and Design

Chapter 2 of this dissertation focuses on the research will be conducted. The philosophy, methodology, approach and process that will be followed are identified and explained.

Chapter 3: Strategic Sustainability Information Management in Higher Education Institutions

The focus of Chapter 3 is to identify the process of managing strategic sustainability information in higher education. The chapter will identify existing frameworks that can be used to support sustainability reporting and management in HEIs.

Chapter 4: Business Intelligence to Support Strategic Sustainability Information Management

Chapter 4 will analyse BI in detail to determine exactly how it can solve the current problems identified in Chapter 3. The chapter will identify the objectives of the BI framework and an initial theoretical BI framework will be proposed.

Chapter 5: Design and Development of the BI Solution (Sustainable BI)

Chapter 5 will detail the design and development of the BI solution. The chapter will outline how the solution will be evaluated as well as the design considerations that need to be accounted for.

Chapter 6: Evaluation Results (Sustainable BI)

Upon completion of the development of the BI solution it will be evaluated to determine to what extent it solves the research problem. The findings from the evaluation will be discussed in Chapter 6.

Chapter 7: Conclusions

The findings of the study will be discussed in Chapter 7. This chapter will conclude the research and provide possibilities for future research in this field.

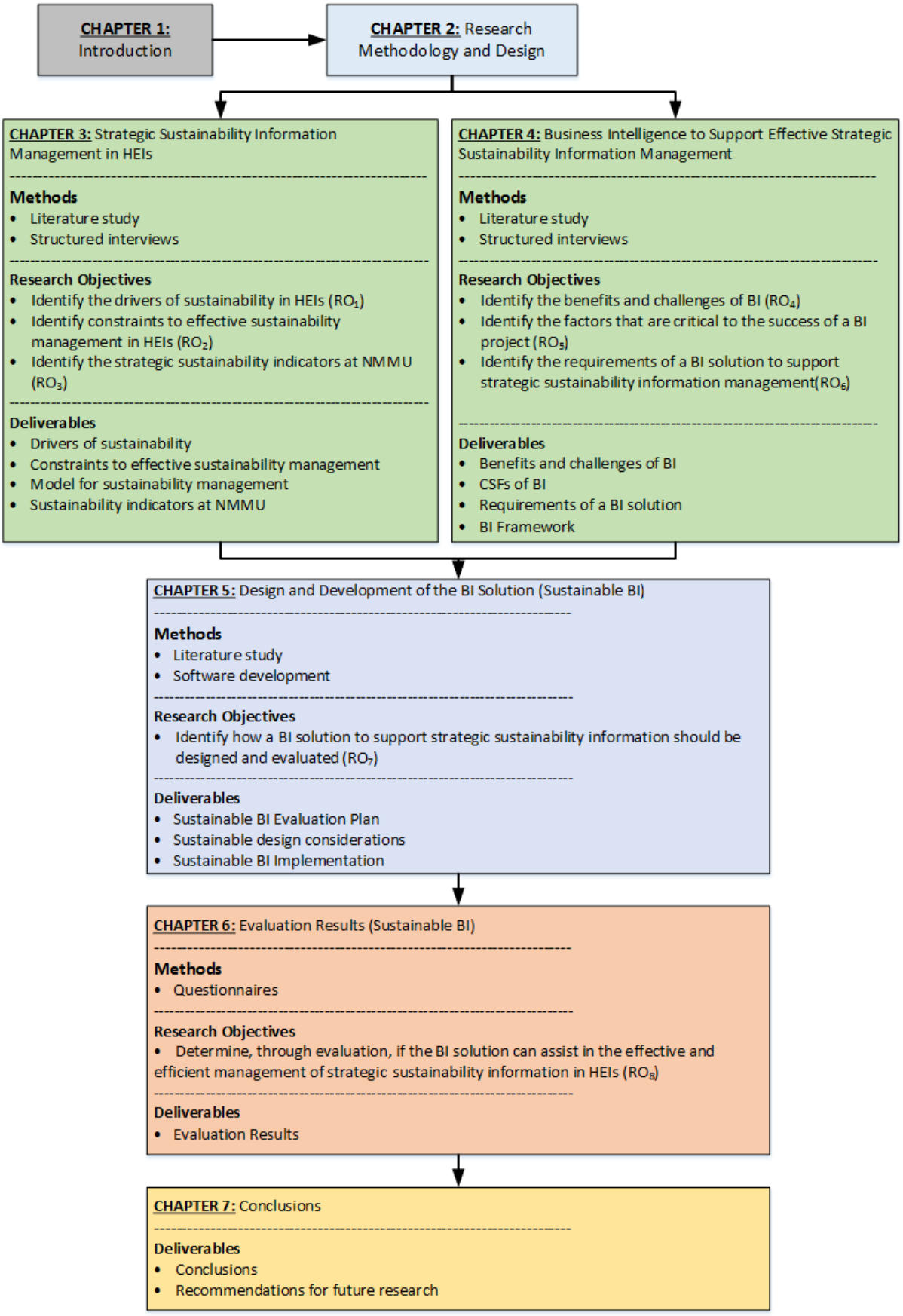

Figure 1-1: Dissertation Structure

Chapter 2. Research Methodology and Design

2.1 Introduction

The previous chapter provided a background and overview of this research. This chapter outlines the methods and processes that will be followed as part of this research. Research design describes and motivates the procedures that will be followed when conducting a research study. Research design is the plan that the researcher will follow to answer the identified research questions (Saunders, Lewis and Thornhill, 2009).

By finding things out, the researcher must contribute to existing theory to make a notable scientific contribution. This chapter outlines the approach that will be followed in this research in order to make a notable contribution to existing theory. There are no research questions associated with this chapter, however the chapter will provide insight into the how the research will be conducted in order to answer all the research questions in this research, and therefore make a noteworthy contribution to existing theory.

This chapter identifies the different research concepts and methods that can be used in research (Section 2.2). The research methodology that will be followed in this research is the Design Science Research (DSR) methodology (Section 2.3). The DSR methodology will be applied in conjunction with the selected research philosophies, approaches and strategies (Section 2.4). Thereafter a summary of the research design is provided (Section 2.5). A full outline of the chapter is provided in Figure 2-1.

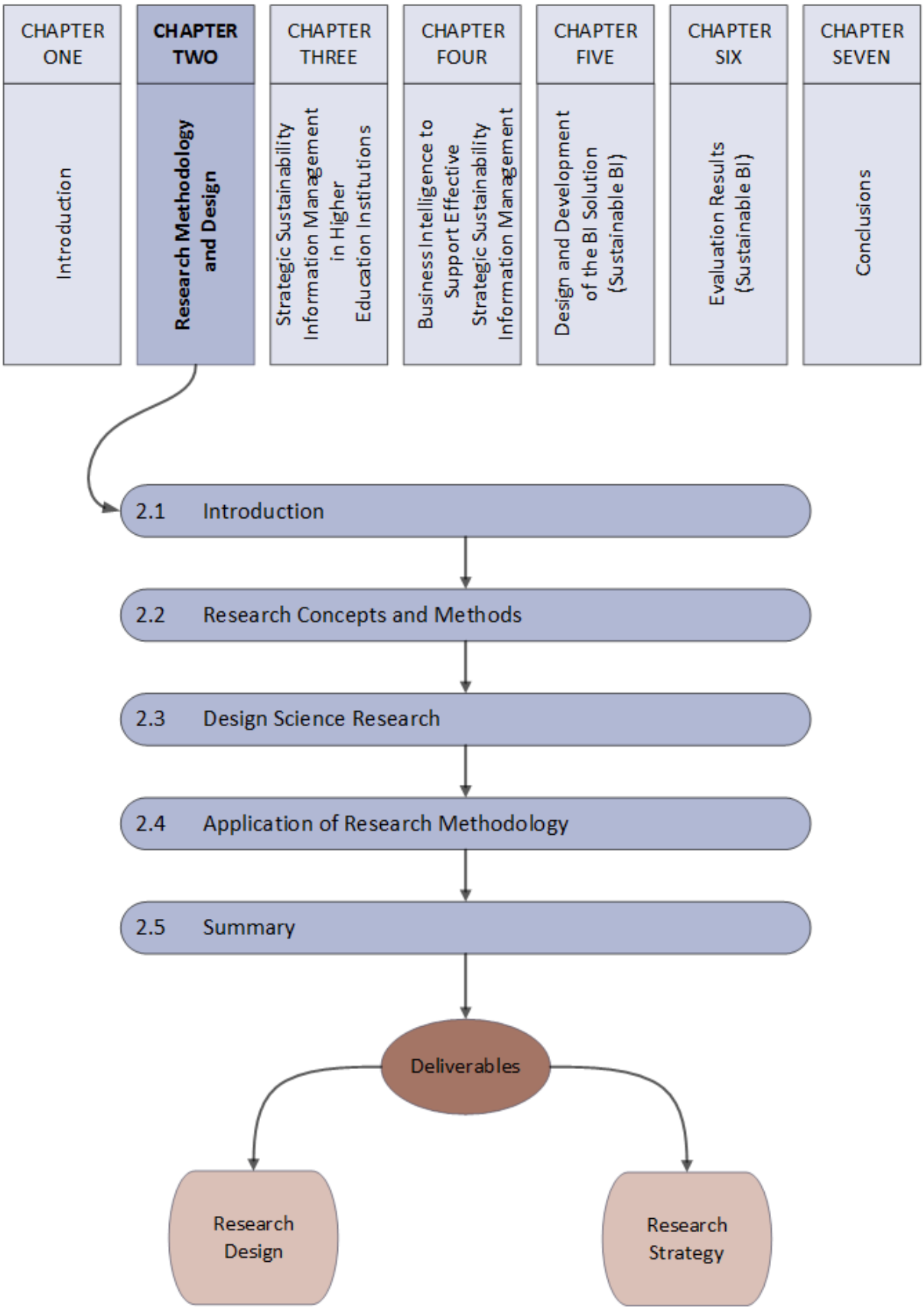

Figure 2-1: Chapter 2 layout

2.2 Research Concepts and Methods

The research onion developed by Saunders et al. (2009) depicts the different components of the research process (Figure 2-2). The research onion consists of several layers, much like a real onion. The outer most layer of the research onion is research philosophy, in which the researcher must determine the most appropriate philosophy for the research being conducted. The second layer of the research onion highlights the research approaches and strategies that the researcher can follow. Following the discussion on the research approaches and strategies that will be followed in this research, attention will be given to the Design Science Research (DSR) methodology, the methodology that will be followed in this research study.

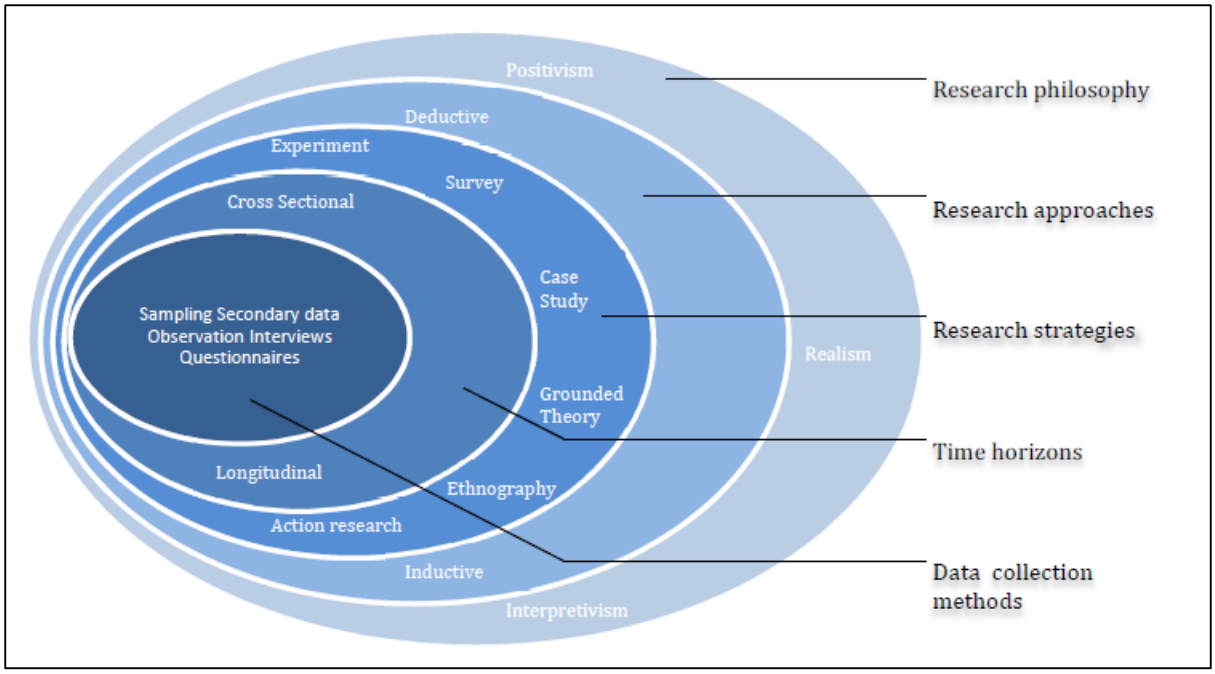

Figure 2-2: The research onion (Saunders et al., 2009)

There are three primary research philosophies, namely positivism, realism and interpretivism (Saunders et al., 2009). Positivism is a paradigm that originated form the natural sciences field and proposes that information can only be merited as knowledge if it is confirmed by ones senses (Bryman, 2012; Macionis and Gerber, 2010). Positivism requires a hypothesis to be developed, objective thinking and knowledge discovery through gathering facts. The positivist approach posits that the researcher's view of reality is indeed a direct review of reality. By using the positivism philosophy, empirical evidence is collected through a highly structured research methodology. Positivism requires observations to be quantifiable and statically analysed (Myers, 2013). The key requirement for the success of a research project following

the positivism philosophy is the objectivity of the researcher (Tekin and Kotaman, 2013). The primary focus of positivism is to test a theory in order to increase the predictive understanding of phenomena (Tekin and Kotaman, 2013).

Interpretivism is a paradigm which follows the school of thought that complex structures of society cannot be reduced to a set of generic laws (Tekin and Kotaman, 2013). Interpretivism differs from positivism as the interpretivist approach is subjective. Interpretivist researchers attempt to understand study subjects from a subjective reality perspective with a view to understanding motives, actions and interactions (Saunders et al., 2009). The realism paradigm focuses on the belief that a reality exists which is independent of human beliefs and thoughts (Tekin and Kotaman, 2013). Realism focusses on challenging the status quo by exposing entrenched structural contradictions within societal systems (Saunders et al., 2009).

There are two primary approaches to research, namely deductive and inductive (Saunders et al., 2009). James (2013) depicts graphically the differences between inductive and deductive reasoning (Figure 2-3). Deductive research follows a top down approach which starts with a theory from which a hypothesis is developed. The hypothesis is subsequently rejected or confirmed through observation.

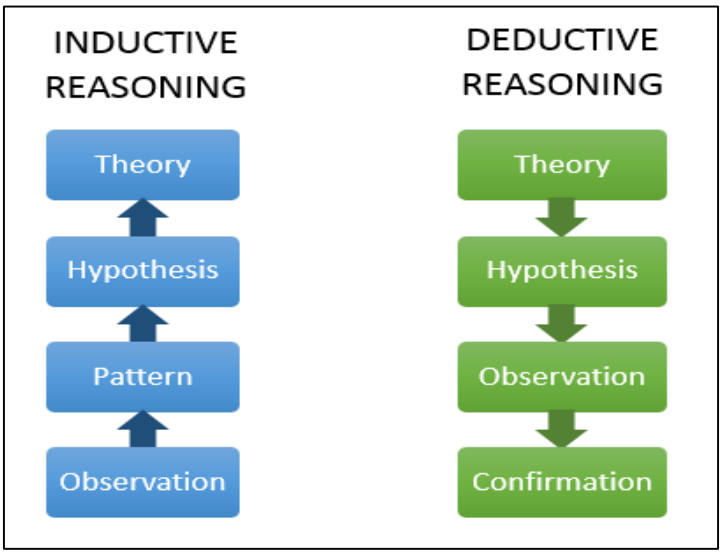

Figure 2-3: Inductive reasoning vs. deductive reasoning (James, 2013)

In contrast to deductive research, inductive research follows a bottom-up approach. An observation is made by the researcher, from which patterns can be determined. These patterns allow for the establishment of a hypothesis, which eventually leads to the development of a

new theory, or a new contribution to an existing theory (Saunders et al., 2009). Common to both inductive and deductive research is the use of a theory.

A research strategy is the overall plan that will be used by the researcher to conduct the research (Johannesson and Perjons, 2014). A clearly defined research strategy is required to answer the proposed research questions. Saunders et al. (2009) and Johannesson and Perjons (2012) identify a number of different research strategies that can be followed:

- Experiment;
- Survey;
- Case study;
- Grounded theory;
- Ethnography;
- Action research; and
- Archival research.

The research strategy to be followed in this research will be a case study. The research will also follow and inductive approach, however no hypotheses are developed.

2.3 Design Science Research

The focus of IT research is on artificial phenomena as opposed to natural phenomena. The focus of IT research is on human creations. Artificial phenomena can be both created and studied and thus both natural and design sciences are relevant to the field. The DSR paradigm is relevant to the field of IT as it addresses two key issues of the discipline: The role of the artefact in IT Research and the perceived lack of relevance of IT research. DSR will be used as the research methodology in this research, and will combine all the layers of the onion discussed in the previous sections of this chapter.

The DSR paradigm supports IT research since it requires innovative artefacts to be developed to solve real-world problems. DSR combines the focus of the artefact with the high priority on relevance in the real world, ensuring that the research provides value. DSR has adapted design research traditions of other fields to support the unique requirements of the IT field. DSR is an emerging IS methodology that borders between system development methodologies and research methodologies. This is an ideal methodology for this research because an artefact, the

BI solution, will be used to solve an existing problem, which is the lack of effective strategic sustainability information management approaches. The BI solution will be the systems development component, whereas the research component will be the development of a BI framework to support strategic sustainability information management in South African HEIs.

The key requirement of DSR is the development of an artefact which aims to solve a relevant organisational problem that can lead to the implementation of the artefact in a real-world situation. DSR is motivated by the need to improve the existing environment by the development of new artefacts that will assist in the improvement of current methods and processes (Hevner, 2007). The BI solution that will be developed in this study can be viewed as the artefact in this research (Hevner et al., 2004), and therefore this paradigm will be suitable for this study. There are two different approaches to DSR namely, the three cycle approach (Section 2.3.1) and the six stage approach (Section 2.3.2), as well as a number of guidelines that should be followed when applying the DSR methodology (Section 2.3.3).

2.3.1 Three Cycle Approach to DSR

The DSR process contains three research cycles (Hevner, 2007). The three cycles are the relevance cycle, the design cycle and the rigor cycle (Figure 2-4). The three cycles of the DSR methodology will be applied in this research which will help in the development of the BI framework. All three cycles will be used.

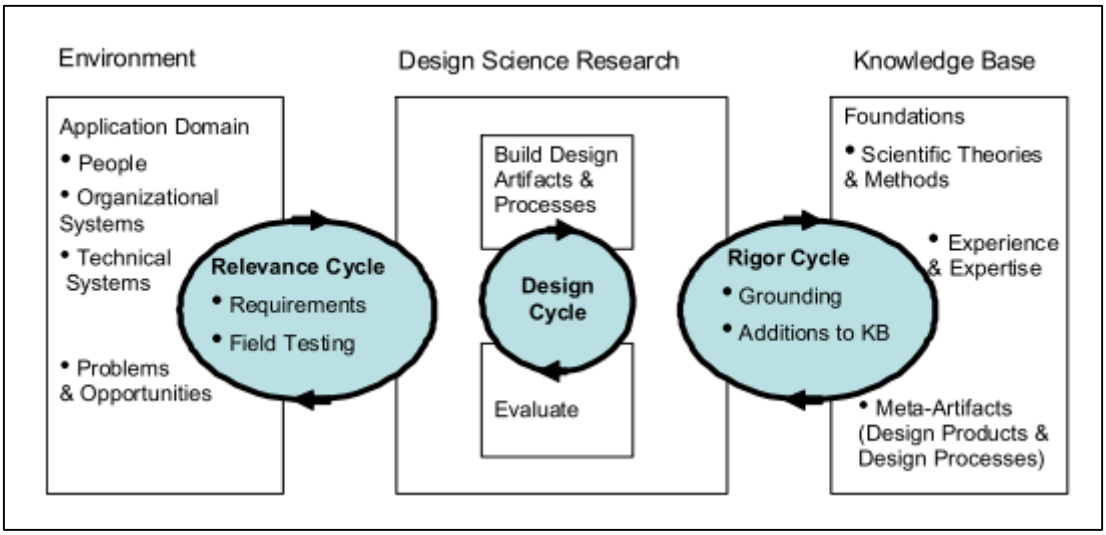

Figure 2-4: Design science research cycles (Hevner, 2007)

Relevance Cycle

Hevner and Chatterjee (2010) propose that good DSR should begin with a good understanding of the opportunities and problems that exist in an application environment. The relevance cycle defines the context of the research and provides the requirements for the research. The acceptance criteria for the ultimate evaluation of the artefact are determined in this phase (Hevner and Chatterjee, 2010; Hevner, 2007). The problems identified in the relevance cycle do not translate directly into the requirements for the given artefact, because the design process should be iterative in nature and should therefore result in incremental solutions (Peffers, Tuunanen, Gengler, Rossi, Hui and Bragge, 2006). The requirements for the artefacts in this research will be determined through a thorough literature review and structured interviews with the relevant stakeholders.

Design Cycle

The design cycle of DSR can be considered the core component of a DSR project (Hevner and Chatterjee, 2010). The design cycle involves developing design alternatives and evaluating the alternatives against the predetermined requirements for the artefact until a satisfactory design is achieved (Hevner, 2007). Artefacts developed must be tested extensively in a test environment before being released for field testing in a live environment (Hevner and Chatterjee, 2010). The development of the artefact requires input from the relevance cycle and the evaluation of the artefact requires input from the rigor cycle (Hevner, 2007). Therefore there is a strong dependence from the design cycle on both the relevance and rigor cycle. Upon completion of the design process, the artefact should demonstrate experimental design and should be able to solve the problem defined in the relevance cycle.

Rigor Cycle

The rigor cycle is responsible for evaluating the artefacts developed in the design cycle. The purpose of the evaluations is to determine to what extent the artefact provides a solution to the given problem (Peffers et al., 2006). The evaluation of the artefact compares the objectives of the solution to the observed results from the evaluation activities. The rigor cycle is responsible for providing past knowledge to the research project (Hevner, 2007). Included in this existing knowledge base is the existing artefacts and processes that exist in the application domain. The researcher should

ensure that the existing knowledge base is thoroughly researched and referenced to ensure that the artefacts produced are new research contributions. The additions to the knowledge base from the research will include any extensions to original theories and methods as well as the experiences gained from performing the research and field testing and usability evaluations of the artefact.

2.3.2 Six Stage Approach to DSR

While Hevner (2007) has developed a three cycle approach to DSR, Peffers et al. (2006) have developed a six stage approach to DSR (Figure 2-5). The two approaches to DSR are similar in that a problem is identified and motivated, the objectives of the solution are determined, the artefact is then developed to solve the unidentified problem using the objectives determined, and the solution is demonstrated and evaluated in the relevant context. Similar to the three cycle approach to DSR, the six stage approach is iterative in nature and with each stage dependencies amongst the different stages.

<u>Stage 1: Problem Identification and Motivation</u>

The purpose of the problem identification stage is to identify and investigate an existing practical problem (Johannesson and Perjons, 2012). The problem should be of interest to a general audience and not significant to just one local practice.

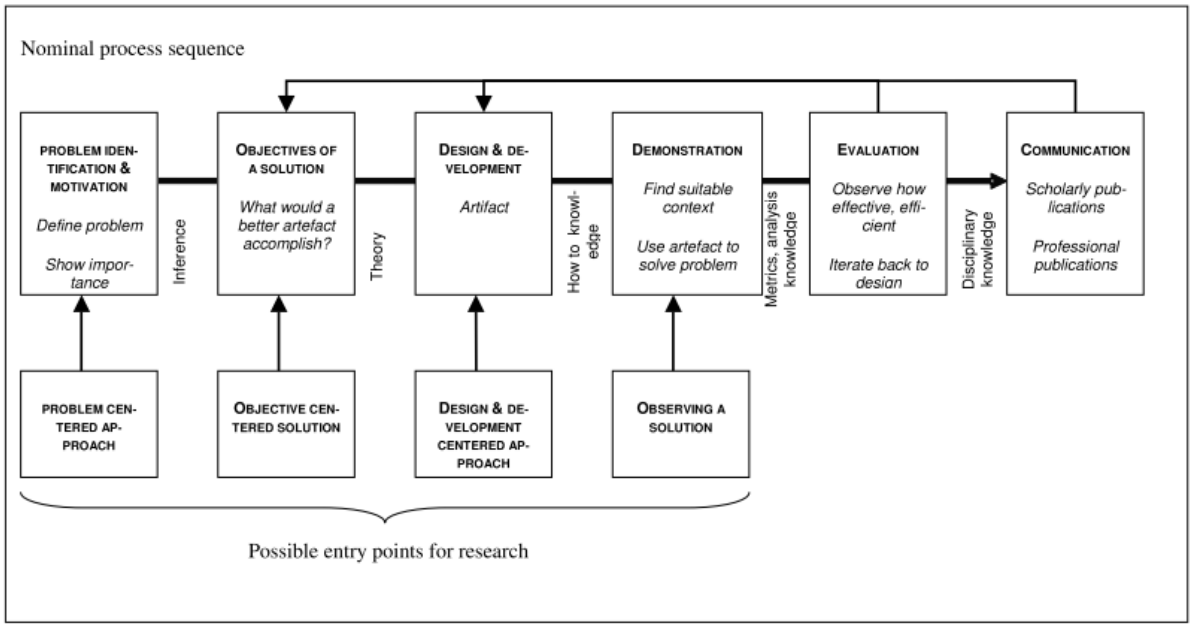

Figure 2-5: The Design Science Research Process (Peffers et al., 2006)

Stage 2: Objectives of a Solution

The second stage of DSR is to identify the objectives of the proposed solution to the problem identified in stage one (Peffers et al., 2006). The solution to the problem should be in the form of an artefact, and the requirements of the artefact should be clearly defined. This stage sees the requirements of the problem transformed into demands of the proposed artefact (Johannesson and Perjons, 2012).

Stage 3: Design and Development

In the third stage of DSR, the proposed artefact should be designed and developed (Peffers et al., 2006). The artefact should address the explicated problem identified in stage one, and fulfil the defined requirements in stage two (Johannesson and Perjons, 2012). The design and development stage includes determining the functionality of the artefact as well as the construction thereof. The artefact to be developed could be one or more of a construct, model, method, framework or instantiation.

Stage 4: Demonstration

In the demonstration stage of DSR, the developed artefact is used in an illustrative or real-life case in order to determine the feasibility of the artefact (Johannesson and Perjons, 2012; Peffers et al., 2006). This stage will help illustrate to what extent the artefact developed in stage 3, meets the requirements outlined in stage 2 to solve the problem outlined in stage 1.

Stage 5: Evaluation

In stage 5 of DSR, the developed artefact is evaluated to determine to what extent the artefact fulfils the identified requirements. This evaluation will help determine to what extent the developed artefact solves the practical problem that motivated the research (Johannesson and Perjons, 2012).

Stage 6: Communication

Communicating the importance of the problem, the artefact and its effectiveness in solving the problem to other researchers and practicing professionals should occur in stage 6 (Peffers et al., 2006). The communication can take place in the form of scholarly research publications.

2.3.3 DSR Guidelines

In the DSR process a number of guidelines should also be followed (Table 2-1) (Hevner et al., 2004). Guideline 1 states that the research needs to produce an artefact. In this study the BI solution that will be developed will be the resultant artefact. Guideline 2 states that the research needs to solve an organisational problem that is relevant and will lead to the artefact being used in a real life situation. In this research, the BI solution will assist in effectively and efficiently managing sustainability in HEIs. The third guideline states that the quality of the system should be ensured through rigorous testing methods. A thorough literature review will provide design guidelines that will be followed and implemented. The design of the system will also be evaluated using expert users.

Table 2-1: Design science research guidelines

Guideline	Description
Guideline 1: Design as an Artefact	Design science research needs to produce artefact in the form of a model, framework or prototype.
Guideline 2: Problem Relevance	The research needs to solve an organisational problem that is relevant and will lead to the artefact being used in a real life situation.
Guideline 3: Design Evaluation	The quality of the system must be ensured through rigorous testing methods.
Guideline 4: Research Contributions	Design science research needs to provide valuable and useful contributions to the domain.
Guideline 5: Research Rigor	Rigorous development and evaluation of the application needs to take place.
Guideline 6: Design as a Search Process	The design of the artefact needs to be a continuing search process, and all available means should be used to reach the final product.
Guideline 7: Communication of Research	The results of design science research must be presented to both technological experts as well as management.

Guideline 4 states that the research needs to provide a valuable contribution to the domain. This research will provide a BI framework and determine the usefulness of BI in effectively managing strategic sustainability. Guideline 5 states that rigorous development and evaluation of the application should take place. A BI solution will be developed to support strategic sustainability management.

2.4 Application of DSR Methodology

Various studies in the BI and performance dashboards field of IS have followed DSR as the core methodology (Lasi, 2013; Vande Moere and Purchase, 2011; Van Zyl, 2014). Whilst the three cycle approach to DSR proposed by Hevner (2007) and the six stage approach to DSR proposed by Peffers et al. (2006) make use of different terminology and a different number of cycles, the two approaches are still similar in nature and can be mapped accordingly (Figure 2-6). The DSR methodology will be applied and followed throughout this research. The Peffers et al. (2006) six stage DSR process will be followed (Figure 2-7) (Section 2.4.1). A number of research strategies will also be applied as part of the DSR process (Section 2.4.2).

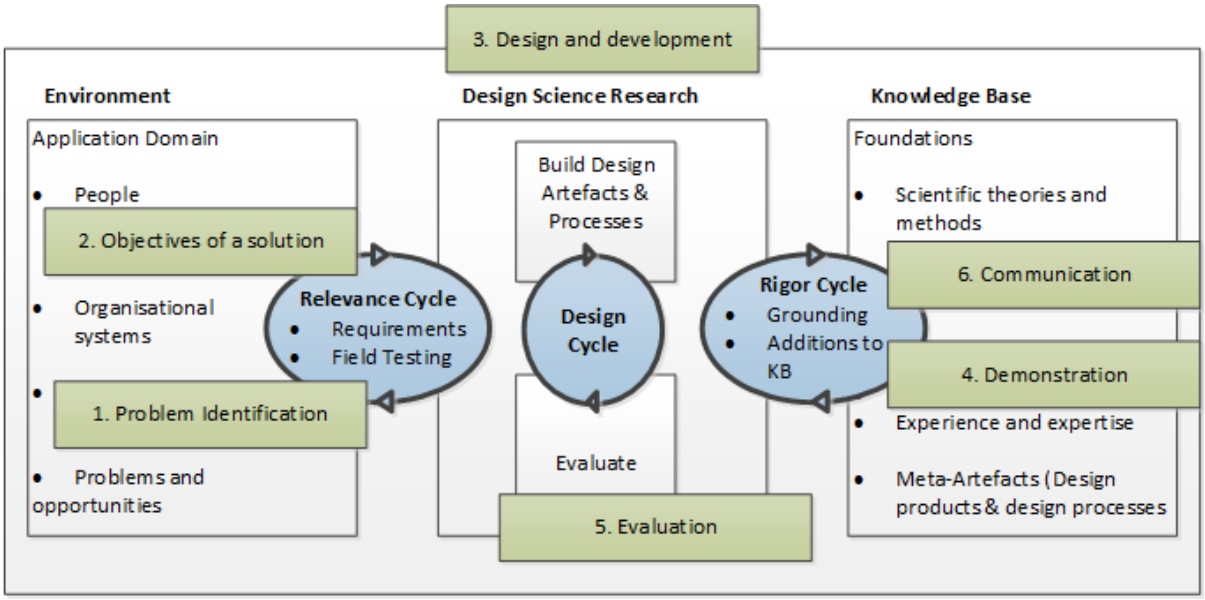

Figure 2-6: Mapping of the three cycle approach to the six stage approach to DSR [adapted from Hevner (2007) and Peffers et al. (2006)]

2.4.1 Application of Six Stage DSR Process

The first stage of the DSR process, identify the problem and motivate, will be applied in Chapter 3, where the problems with strategic sustainability information management in HEIs are identified. The second stage of the process, define objectives of a solution, will be applied in Chapter 4, where a possible solution to the problem will be identified as well as the specific objectives and requirements of the solution. In this research, BI, is the proposed solution to the problem of strategic sustainability information management. The third phase of the process, design and development, will be carried out in Chapter 5.

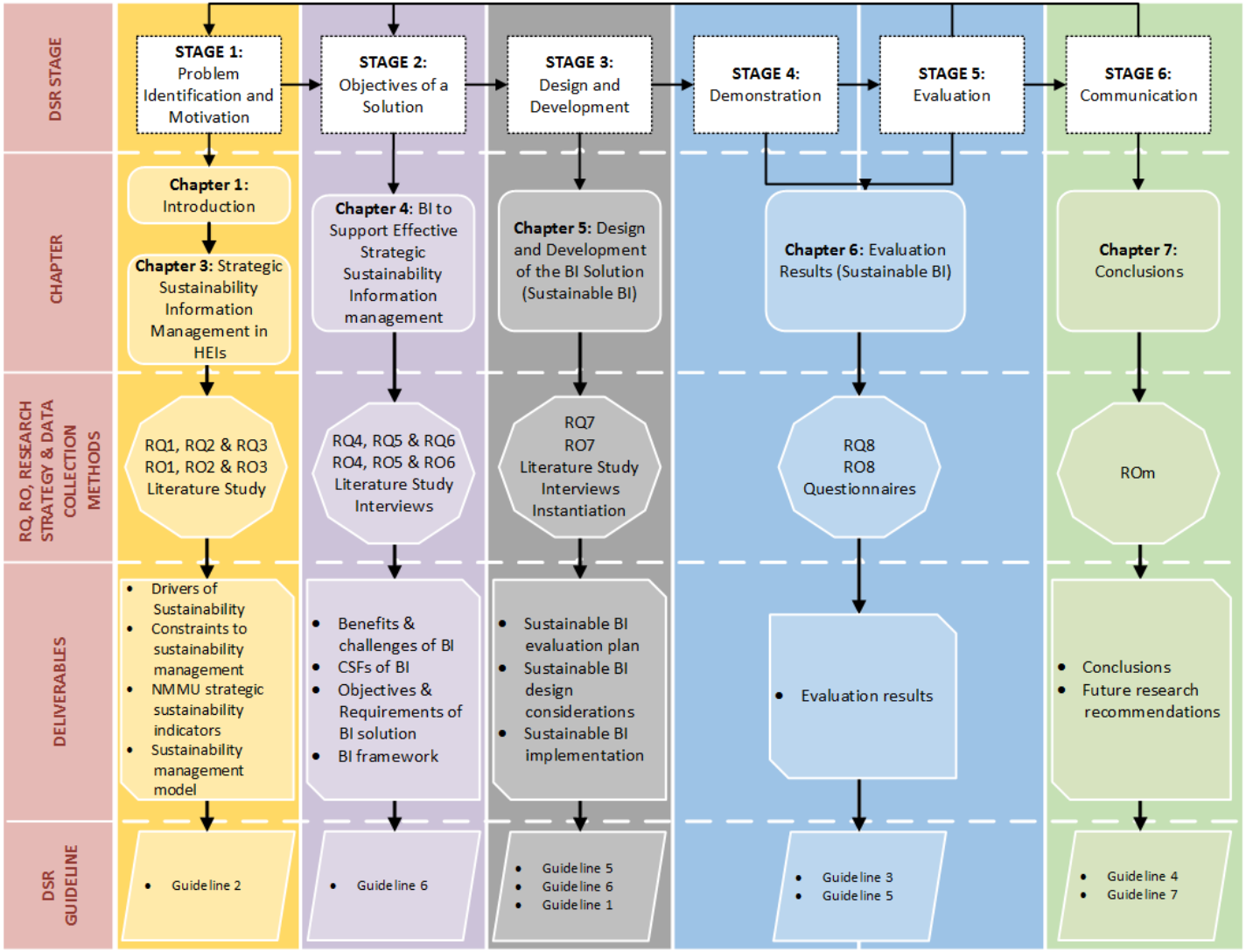

Figure 2-7: Chapter layout mapped to DSR methodology

The design and development of the proposed BI solution will be explored in detail. The developed BI is one of the artefacts that will be produced by this research. Upon completion of the development of the BI solution, the artefact will be demonstrated and evaluated using the relevant stakeholder. The evaluation and demonstration phases of this research will take place in Chapter 6. The final stage of the process, communication, will take place in Chapter 7, where the findings of the research will be communicated to the reader.

2.4.2 Research Strategies and Data Collection Methods

In conjunction with the DSR methodology, this research will make use of a case study and structured interviews. In addition, a literature study will be conducted to gain a better understanding of the problems with strategic sustainability information management, as well as the proposed solution, BI.

NMMU will be used as the case study for this research. NMMU has identified sustainability as a key strategic goal, which highlights NMMU's commitment to better managing sustainability. The focus of the study is the management of strategic sustainability information in HEIs, a problem that is currently faced by NMMU. The proposed BI solution will be focussed specifically on NMMU, making use of NMMU's data and NMMU's strategic sustainability indicators. The purpose of the structured interviews is to gain a better understanding of the challenges that NMMU faces in manging strategic sustainability information, as well as gaining a better understanding of the current status of BI at NMMU, the proposed solution to the problem. An extant-systems analysis will also be conducted to determine the capabilities of the current tools available. Interviews will be used in this research to gain an insight into existing sustainability management methods at NMMU. Interviews will be used to determine the state of BI at NMMU, and the requirements of a BI solution to support effective sustainability management at NMMU.

Questionnaires are used frequently in research to collect data, often numerical in nature, without requiring the physical presence of the principle researcher (Cohen et al., 2011). Keller (2005) noted the following about questionnaires:

- The success of a questionnaire is dependent on its design;
- Questionnaires should be as short as possible to encourage completion by the participants;

- The questionnaire should include simple demographic questions; and
- Open-ended questions are useful for gaining greater insight into the participant's opinions. However these questions are more difficult to analyse.

The questionnaires will be used to assist in determining if the proposed BI solution can assist in more effectively managing strategic sustainability information. A usability evaluation will be conducted on the proposed BI solution, after which the participants will be required to complete a questionnaire.

2.5 Summary

The chapter discusses in detail the chosen methodology of DSR. The use of DSR in IT is also discussed, highlighting why it is the chosen methodology for this research. The DSR methodology, according to Hevner (2007), involves three separate cycles that should be followed. Peffers et al. (2006) proposed that DSR consists of six stages however. For the purpose of this study, the six stage approach proposed by Peffers et al. (2006) will be followed. The strategy that will be used in this research to answer the defined problem statement was discussed. This research will make use of a literature review, surveys and a usability study to determine in an attempt to solve the given problem. The processes that will be followed in this research are discussed, with the processes based on the six stages of DSR outlined by Peffers et al. (2006).

The following chapter focusses on the problem identification stage of the DSR process. The chapter focusses identifying the problems with strategic sustainability information management in HEIs.

Chapter 3. Strategic Sustainability Information Management in Higher Education Institutions

3.1 Introduction

In Chapter 2, Design Science Research (DSR) was identified as the research methodology that will be used in this study. According to Peffers et al. (2006), DSR follows six iterative stages, of which problem identification and motivation is the first stage (Figure 3-1). In this stage, the researcher should identify the existing problem and create a more detailed problem definition. In order to gain a clearer understanding of the existing problem of this study, strategic sustainability management in HEIs is explored in more detail in this chapter.

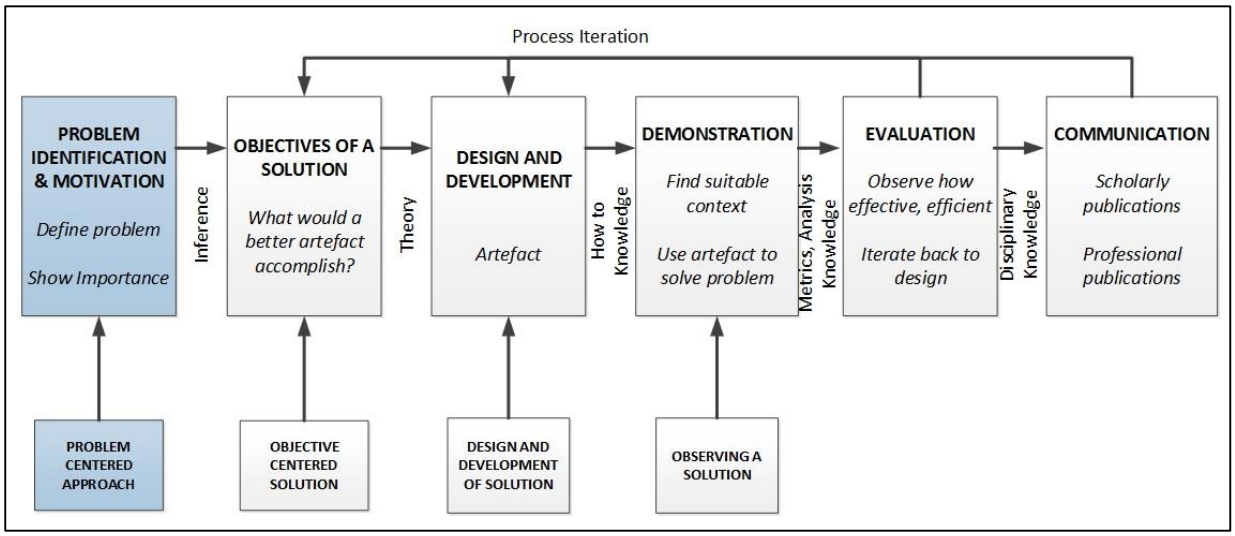

Figure 3-1: Problem identification and motivation stage of DSR (Peffers et al., 2006)

This chapter seeks to answer three separate research questions, namely:

- RQ_1: What are the drivers of sustainability in HEIs?
- RQ_2: What are the constraints to effective sustainability management in HEIs? and
- RQ_3: What are the strategic sustainability indicators at NMMU?

Finding answers to these questions will form part of the first stage of the DSR process, namely problem identification and motivation. By answering these research questions a number of deliverables will be produced. These deliverables are the drivers of sustainability in HEIs, the

constraints to effective sustainability management in HEIs, the strategic sustainability indicators at NMMU and a model of sustainability management.

Sustainability should be at the forefront of an organisation's governance policy and strategic plan (Section 3.2). This is no different in HEIs, where sustainability is becoming an increasingly more important issue (Section 3.3). Organisations are beginning to see the many benefits sustainability reporting provides (Section 3.4). These benefits associated with sustainability reporting have seen a growth in sustainability reporting in HEIs (Section 3.5). This is no different in South Africa, where the benefits of sustainability reporting coupled with the new regulatory requirements have seen an increase in sustainability reporting by South African HEIs (Section 3.6). In order to enable organisations to produce sustainability reports, a number of dedicated sustainability reporting tools have been developed (Section 3.7). Whilst sustainability reporting is a key component in managing sustainability, there are still many constraints to effective sustainability management (Section 3.8). The development of a Sustainability Management Model can assist HEIs to gain a better understanding of the interrelated components of sustainability management (Section 3.9). NMMU is a South African HEI that has made sustainability a key strategic priority and therefore serves as the case study for this research (Section 3.10). In order to effectively manage sustainability, a dedicated information system (IS) is required (Section 3.11). A full outline of the chapter is provided in Figure 3-2.

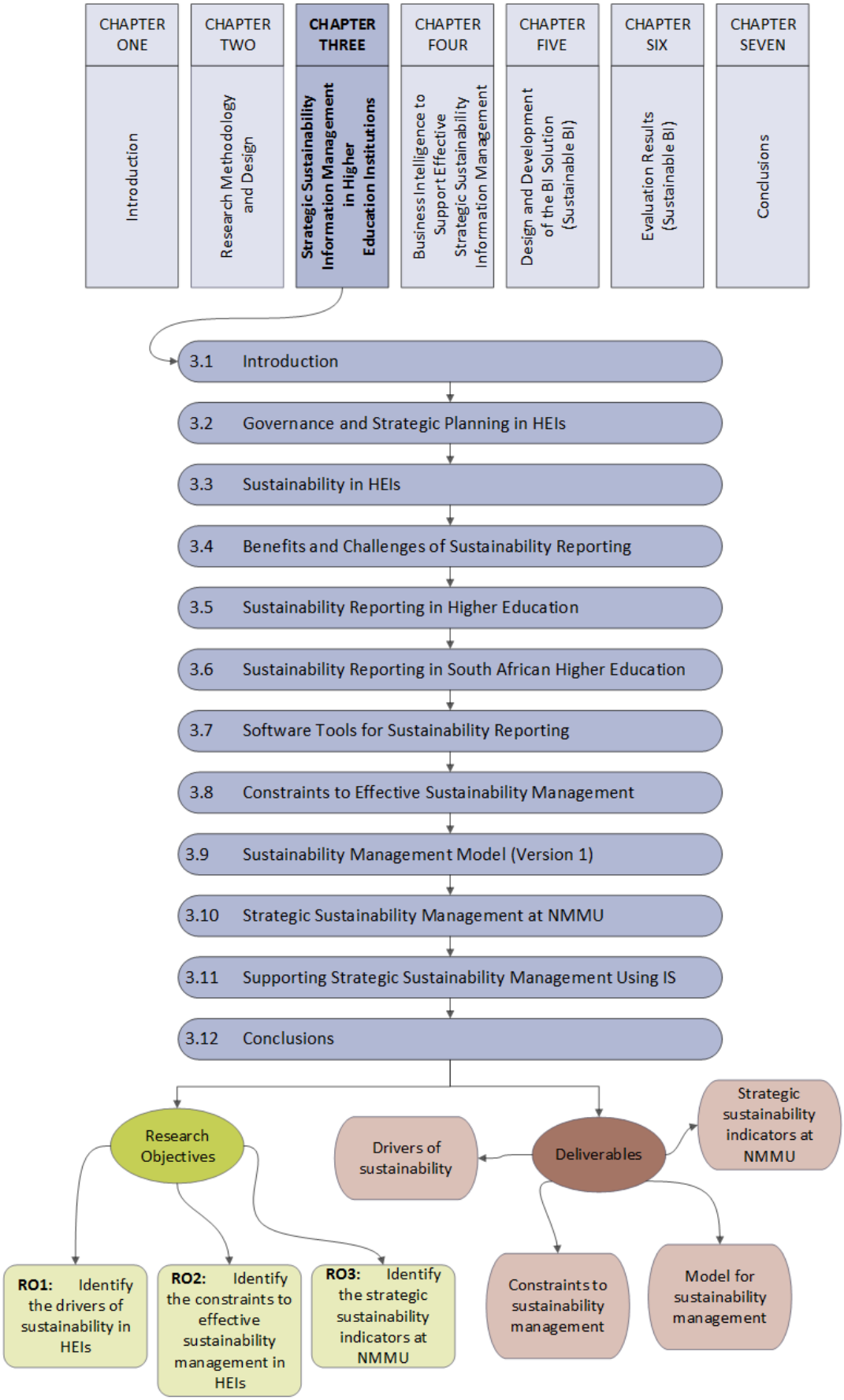

Figure 3-2: Chapter 3 layout

3.2 Governance and Strategic Planning in HEIs

Governance within organisations has attracted great attention due to high-profile governance failures in global corporations such as Enron, Woldcom and Tyco (Tetteh and Ofori, 2010). The focus on good corporate governance in all organisations has increased significantly because of these high-profile failures. Corporate governance can be defined as the set of systems, principles and process by which an organisation is governed (Thomson, 2009). In any organisation, sound governance structures are critical to the development of reports that address sustainability issues (Adams, 2013). In South Africa, King III (2009) is seen as the cornerstone of corporate governance for companies. King III underscores the importance of sustainability reporting. King III's (2009) core philosophy revolves around leadership, sustainability and corporate citizenship, which has extended the scope of corporate governance in South Africa.

The King III standards are the standards under which South African HEIs operate (Bosire, 2014). Governance practices in South African public HEIs are coming under increasing scrutiny in light of the number of these institutions that are under government administration. Poor governance in these institutions is seen as the major cause of maladministration. In order to ensure that HEIs operate effectively and can be sustainable in the long-run, it is imperative that good governance practices be adopted and followed (Steyn and De Villiers, 2005) (Steyn and De Villiers, 2005). The Council is ultimately responsible for good governance structures in South African HEIs (Bosire, 2014). This points towards effective management of sustainability at a strategic level.

The council usually consists of the institution's chancellor, vice-chancellor, deputy vice-chancellors and other senior management (Bosire, 2014). The institution's council is supported by the senate, executive management and institutional forum. The Senate deals with academic matters from both faculties and departments. The executive management is responsible for ensuring that the institution's operations run optimally. The institutional forum allows other staff members and students to contribute to the management of the university.

The King III report, the governance guidelines for South African organisations, highlights that good governance, strategic planning and sustainability management are inseparable (Institute of Directors, 2009). The report also recognises the importance that a clearly outlined strategic plan has on the long-term sustainability of organisations. Sayed and Asmuss (2013) highlight

the relationship between good governance and sustainability (Figure 3-3). The education, research, operations and community engagement components are all key components of the Sustainability Tracking, Assessment and Rating System (STARS), a leading sustainability reporting and assessment framework developed for HEIs. In addition to the four STARS components, governance should be at the centre of all sustainability efforts, as highlighted by Sayed and Asmuss (2013).

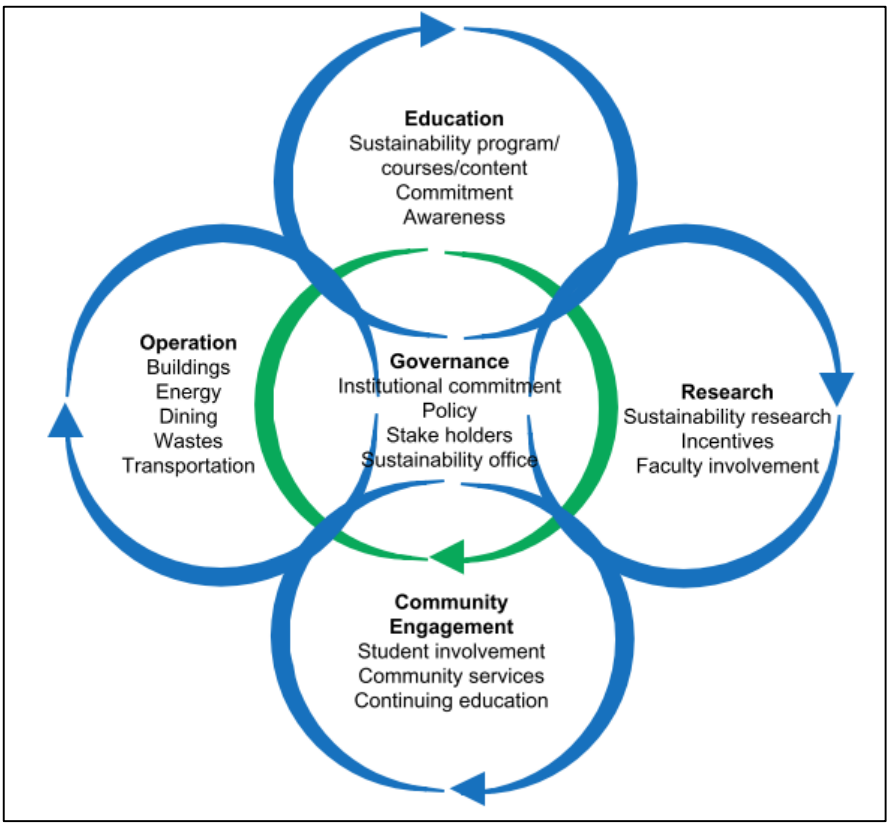

Figure 3-3: General sustainability practice of HEIs (Sayed and Asmuss, 2013)

The fast-changing and volatile environments in which HEIs operate increases the need for long-term strategic plans (Richards, O'Shea and Connolly, 2004). The strategic planning process can assist an organisation with creating a sustainable environment. Organisations can use strategic planning to determine long-term goals and develop policies and procedures geared towards obtaining these goals (Nickels, McHugh and McHugh, 2008). Strategic planning should be viewed as a planning instrument that allows for the development of long-term plans to support the long-term sustainability of the organisation (Özdem, 2011). These plans should identify both future and current risks and opportunities of the organisation, and should include a continuous evaluation of the organisation's strengths, weaknesses and resource requirements.

A firm understanding of these aspects can help the organisation to understand the future prospects and sustainability of the organisation.

Strategic planning in higher education has become increasingly important due to the increase in public scrutiny for better accountability in HEIs. The public nature of these institutions requires them to be transparent and the disclosure of certain information is a legal requirement. The new reporting requirements imposed on South African HEIs require institutions to produce an annual strategic plan identifying the institution's vision, mission, policy, priorities and project plans for at least a five year period (Department of Higher Education and Training, 2014). The plan should also clearly identify the strategic goals and objectives of the institution.

Sustainability is becoming an important dimension of an organisation's corporate strategy (Neto and Froes, 2001; Zadek, 2005) and a multilevel challenge that requires strategic thinking. However, a review of strategic planning documents of HEIs by Adams (2013) highlighted the lack of attention given to sustainability at a strategic level. Few HEIs pay much attention to material sustainability challenges, issues and risks in their strategic plans. Many of these institutions that include sustainability in their strategic plans or have sustainability specific plans focus on operational sustainability impacts which are trivial to the impact of the institution on sustainability through its core operations.

3.3 Sustainability in HEIs

HEIs should play a leading role in promoting sustainability awareness and act as a driver of change towards a sustainable world (Lozano, Lukman, Lozano, Huisingh and Lambrechts, 2013). Paraschivescu and Radu (2011) report that HEIs should be at the forefront of global sustainability efforts. The International Association of Universities is attempting to promote sustainability awareness in HEIs globally. HEIs in the United States (US) are facing increasing demands for accountability from the federal government with regard to disclosure of organisational performance and sustainability (Durso, 2009). This greater demand for accountability by HEIs in the US could be the start of a trend that could become a standard for HEIs globally.

The old adages of "*what gets measured, gets done*" and "*if it can't be measured it can't be managed*" are beginning to be applied to sustainability efforts in HEIs (Shriberg, 2011). While many HEIs have begun integrating sustainability into their visions and developing

sustainability strategies, the successful implementation thereof requires the application of an effective, sustainability information management tool that covers all aspects of sustainability (Windolph, Schaltegger and Herzig, 2014).

In many HEIs, sustainability initiatives are led by students or academics rather than by including sustainability initiatives as a strategic priority led by strategic management (Adams, 2013). However HEIs, globally, are beginning to recognise the importance of effectively managing sustainability and are starting to adjust their missions and visions to include sustainability into both their business and educational processes (Stephens and Graham, 2010). Becoming a sustainable institution is a long-term and multi-level challenge that requires the integration of sustainability initiatives into the organisational strategy (Goni et al., 2013). A number of factors are driving the HEI transformation towards becoming a sustainable institution (Holmberg and Samuelsson, 2006). Drivers of sustainability can be both internal and external (Figure 3-4).

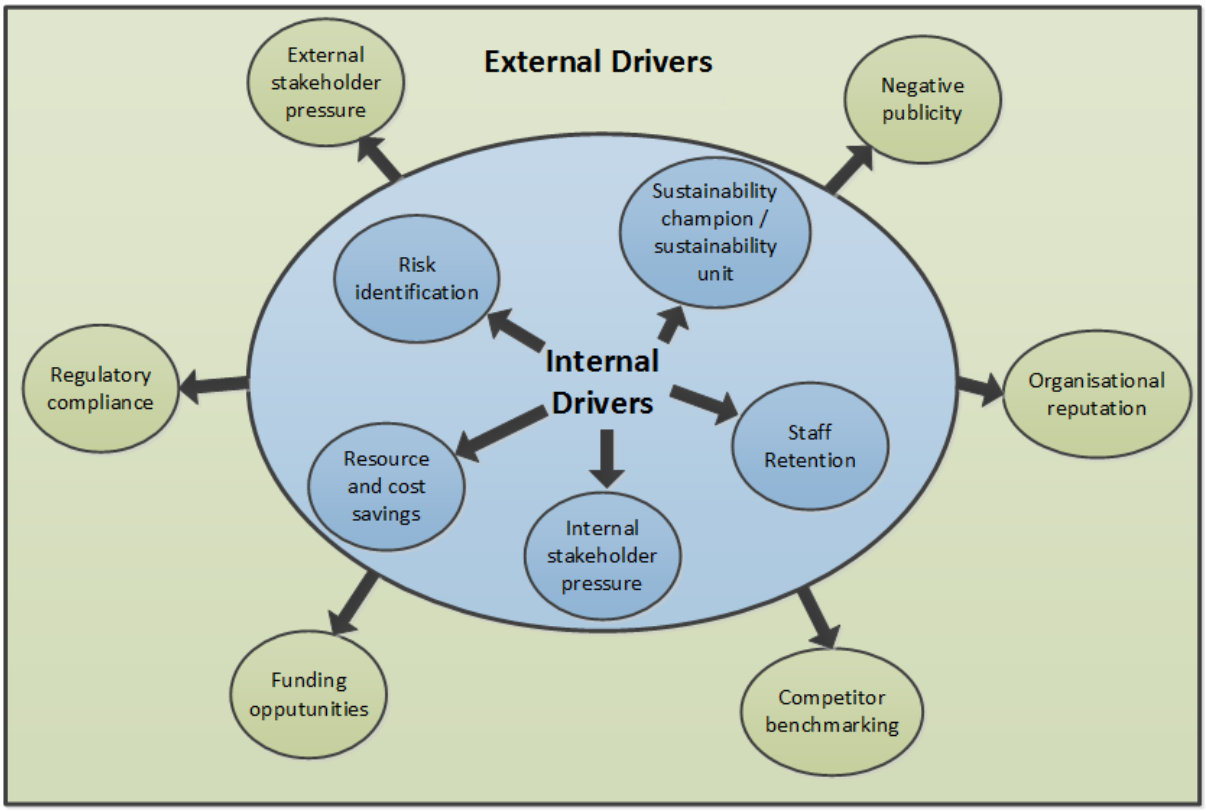

Figure 3-4 Drivers of sustainability in HEIs (Author's own construct)

Internal drivers are usually more proactive, whereas external drivers are usually more reactive (DeSimone and Popoff, 2000). An analysis of existing literature revealed six common external drivers of sustainability initiatives.

These six external drivers are:

- regulatory compliance (Frehs, 2003; Holmberg and Samuelsson, 2006);
- increased pressure from external stakeholders (Busse, 2004; Holmberg and Samuelsson, 2006);
- funding opportunities (Dhaliwal, Li, Tsang and Yang, 2011; Holmberg and Samuelsson, 2006);
- competitor benchmarking (Quazi, 2001);
- enhanced organisational reputation (Dunphy, Griffiths and Benn, 2014; Frehs, 2003; Oskarsson and Von Malmborg, 2005); and
- the negative publicity associated with a lack of sustainability efforts.

The growing awareness of the importance of sustainability has led to the development of laws and regulations requiring organisations, including HEIs, to disclose their sustainability efforts (Frehs, 2003; Holmberg and Samuelsson, 2006). This is no different in South Africa where the new regulations outlined by the Department of Higher Education and Training (2014), which requires all public HEIs to produce annual sustainability reports. This increased awareness in the importance of sustainability has also seen external stakeholders place increasing pressure on organisations to openly disclose this information. Organisations that openly disclose sustainability information, are more likely to be backed by investors, which increases the chances of receiving external funding and sponsorships (Dhaliwal et al., 2011; Holmberg and Samuelsson, 2006). The increased competition in the higher education sector has also led to HEIs benchmarking performance against each other (Quazi, 2001). This is no different to sustainability. Publically disclosing sustainability information can also lead to an enhanced reputation for the organisation with external stakeholders (Dunphy et al., 2014; Frehs, 2003; Oskarsson and Von Malmborg, 2005). On the contrary, however, HEIs face the possibility of receiving negative publicity if there is a lack of sustainability efforts taking place within the institution.

Internal drivers of sustainability include:

- sustainability champions or sustainability units (Holmberg and Samuelsson, 2006);
- risk identification (Dunphy et al., 2014);
- resource and cost savings (Henriques and Richardson, 2005; Quazi, 2001);
- staff retention (Quazi, 2001); and
- pressure from internal stakeholders (Laffer, Coors and Winegarden, 2004).

At a number of institutions there are sustainability units or champions that push for the inclusion of sustainability into the operations of the institution (Holmberg and Samuelsson, 2006). Proper management of sustainability can also enable an institution to identify risks that would otherwise not have been identified (Dunphy et al., 2014). The institution can also reduce resources and minimise savings through cutting costs through proper sustainability management (Henriques and Richardson, 2005; Quazi, 2001). Staff retention can also improve as employees will be less likely to leave the organisation if it promotes sustainability in its operations (Quazi, 2001). The pressure these staff members and other internal stakeholders place on HEIs to operate more sustainably can also drive sustainability awareness.

Bosire (2014) identified several interrelated factors that affect sustainability management in South African HEIs (Figure 3-5). Sustainability management in South African HEIs consists of three main categories, namely structures, processes and infrastructure. The structures includes all governance practices to which HEIs should comply. These practices are outlined in the King III report which is seen as the foundation for South African governance practices (Institute of Directors, 2009).

The processes category includes both strategic planning and sustainability reporting, which are dependent on each other. The infrastructure category includes BI, which allows for improved sustainability reporting and strategic planning. BI enables improved data management and provides management with a constant stream of real-time up-to-date information (Sabherwal and Becerra-Fernandez, 2011). Therefore it can be deduced that BI can facilitate improved sustainability information management and the provision of real-time up-to-date sustainability information.

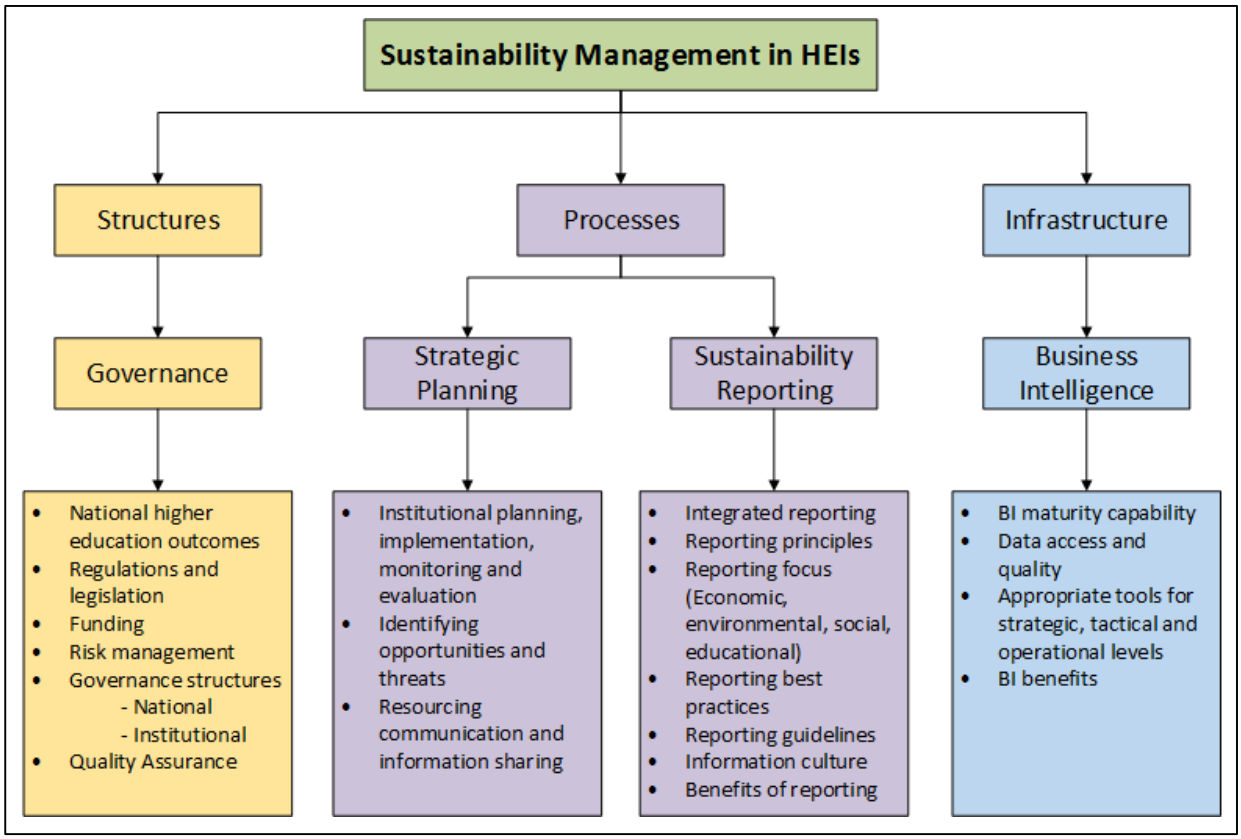

Figure 3-5: Factors affecting sustainability management in HEIs (Bosire, 2014)

The management of sustainability differs at the different organisational levels and therefore the information requirement differs at these levels (Figure 3-6). The first factor that differentiates sustainability at different organisational levels is decision-making (Goni et al., 2013). At the strategic level, sustainability objectives are consistent with the organisation's mission statement and organisational strategies are developed to achieve these sustainability objectives. Strategic sustainability decisions are long-term in nature and affect the shape and direction of the entire organisation. Senior top-level managers are usually responsible for strategic sustainability decision-making. Long-term forecasts of sustainability practices relating to both internal and external practices will help senior management make decisions and determine if strategic sustainability objectives are being met. The main focus of managers at the strategic level of an organisation is to monitor and manage the organisation's performance (Hulsebosch, Turpin and Wagenaar, 2009). In the context of sustainability, strategic-level managers are required to monitor sustainability information to determine if the organisation is meeting its long-term sustainability goals.

The tactical level of an organisation is responsible for the planning of sustainability transformation and the forecasting of these initiatives (Goni et al., 2013). Tactical decisions are

usually made by middle-level management and help the organisation to implement sustainability strategies. The operational level deals with day-to-day sustainability decisions. These decisions are usually short-term in nature.

Figure 3-6: Sustainability at different organisational levels in HEIs (Author's own construct)

3.4 Benefits and Challenges of Sustainability Reporting

A key factor thwarting the inclusion of sustainability into organisational strategy and strategic plans is the difficulty which firms face in monitoring the indicators that cover all the different dimensions of sustainability (Petrini and Pozzebon, 2009). Sustainability reporting is one mechanism used by organisations to track their performance against their goals and objectives. Measuring sustainability efforts enables more effective management of sustainability performance, which can help to identify areas of possible improvement (Adams, 2013).

Sustainability reporting aims to disclose key sustainability information to both internal and external stakeholders in a standardised report. A survey conducted by KPMG (2011) found

that 95% of the world's largest 250 companies have a sustainability strategy and publically disclose sustainability information through sustainability reports. The survey also found that the highest reporting rates are associated with European organisations, although North American organisations and emerging markets continually register phenomenal growth. The benefits realised by sustainability reporting has been one of the key drivers of its growth in recent years. HEIs are starting to see the importance of sustainability reporting, with reporting frameworks and guidelines now being established specifically for HEIs.

Sustainability reporting should not be done merely to be compliant with regulations. The advantages that sustainability reporting provides have caused more organisations to voluntarily report, with the management of sustainability now high on the agenda (Boston College Center for Corporate Citizenship and Ernst & Young, 2013). Sustainability reporting can provide several benefits to an organisation such as:

- Improved financial performance (Plumlee, Brown and Marshall, 2010);
- Access to capital (Dhaliwal et al., 2011);
- Innovation, waste reduction and improved efficiency (Global Reporting Initiative, 2014; Hull and Rothenberg, 2008);
- Improved risk management (Boston College Center for Corporate Citizenship and Ernst & Young, 2013);
- Improved reputation and consumer trust (Boston College Center for Corporate Citizenship and Ernst & Young, 2013); and
- Improved loyalty and recruitment (Crifo and Forget, 2012).

Organisations are increasingly finding that positive social and environmental performance can lead to improved financial performance (Plumlee et al., 2010). Compliance costs can also be reduced as sustainability management can help organisations to meet regulatory requirements more effectively (Global Reporting Initiative, 2014). Research from Dhaliwal et al. (2011) suggests that there is increased access to capital since investors and sponsors are more willing to invest in organisations that take the management of sustainability seriously. This is important for HEIs as funding from sponsors is one of the key funding streams (Bosire, 2014). Internal management and the decision-making process can be analysed and optimised. This can enable cost savings for the organisation as expenses relating to energy consumption, materials use and waste can be better managed (Hull and Rothenberg, 2008). Organisations can more easily predict and manage areas of risk from sustainability related areas of the organisation (Boston

College Center for Corporate Citizenship and Ernst & Young, 2013). Sustainability reporting and voluntary disclosure can greatly enhance the reputation and consumer trust of an organisation. A better reputation can lead to customer growth for organisations. In the field of higher education, this can lead to the base of prospective students growing (Boston College Center for Corporate Citizenship and Ernst & Young, 2013). Proactively disclosing and communicating an organisation's corporate responsibility commitments has a positive impact on productivity of employees (Crifo and Forget, 2012). A reputation of strong sustainability management and reporting as well as corporate social responsibility can also enhance employee loyalty and recruiting efforts.

While sustainability reporting can enable an organisation to realise many benefits, a number of challenges exist. Many of the challenges of sustainability reporting relate to the underlying data. The availability of data and the accuracy and quality of the data are two challenges that many organisations face with sustainability reporting (Boston College Center for Corporate Citizenship and Ernst & Young, 2013). Poor quality and accuracy of data increases the time and workload required to generate high-quality sustainability reports. Many organisations struggle to gain internal buy-in to generate and disclose sustainability reports. The voluntary nature and lack of regulations regarding sustainability reporting is a contributing factor to the poor buy-in (Bosire, 2014; Boston College Center for Corporate Citizenship and Ernst & Young, 2013). The poor regulatory requirements also lead to many organisations withholding these reports as they view the information as proprietary. Many organisations track this information internally but do not publically disclose it as they do not see the benefits of doing so, whilst some organisations that wish to produce and disclose sustainability reports do not have the necessary resources to do so. These resources include both personnel and software tools. This is particularly relevant to HEIs in which the use of BI tools is very limited. Bosire (2014) and Pina (2011) identified BI as a key enabler of sustainability management and reporting.

Many organisations are beginning to realise that the benefits associated with generating and publically disclosing sustainability reports outweigh the associated challenges and costs (Boston College Center for Corporate Citizenship and Ernst & Young, 2013; Price Waterhouse Coopers, 2008). This has led to considerable growth in the number of organisations publically disclosing sustainability reports.

3.5 Sustainability Reporting in Higher Education

Adams (2013) established that only a small proportion of HEIs, globally, produce annual sustainability reports using globally accepted guidelines and frameworks. The upsurge in sustainability reporting in the corporate world, however (Aras and Crowther, 2009; Daub, 2007; Kolk, 2010), has seen an increasing number of HEIs reporting on their sustainability efforts (Ceulemans, Molderez and Van Liedekerke, 2014). Although, in number, there is a growing trend of sustainability reporting in HEIs, the number of institutions producing sustainability reports is still limited. This is supported by Lozano (2011) who reported that sustainability reporting is still in its infancy in HEIs, because of both the lack of institutions producing reports and the poor quality of these reports. Given the important role that the reporting process plays in the development of data collection systems and performance management, this low level of sustainability reporting highlights the poor management of sustainability in HEIs (Adams, 2013). Sustainability reporting is an important process in the movement towards a sustainable university.

The growing number of sustainability initiatives and reporting standards is evidence of the increasing importance of sustainability management (Institute of Directors, 2009). The increased pressure from stakeholders for accountability from organisations has led to the development of a number of new reporting standards (Pennington and Moore, 2010). A KPMG (2013) report found that there are 142 different standards and laws on sustainability in over 30 countries. Examples of these reporting standards include the GRI, ISO 14000 series, Triple Bottom Line, Natural Step, Compass Sustainability, Dow Jones Sustainability Index, STARS and the Fortune Corporate Reputation Rating (Lozano, 2006). This section presents an overview of two different reporting Standards: the GRI and STARS. The GRI is one of the more comprehensive and globally accepted frameworks (Section 3.5.1.1). The second framework, the STARS framework, is developed specifically for HEIs (Section 3.5.1.2).

3.5.1.1 Global Reporting Index (GRI)

Despite the growing importance of sustainability management, a global reporting standard across all countries and sectors does not exist. The GRI seeks to address this problem by providing comprehensive guidelines for sustainability reporting, which guidelines cover the entire spectrum of an organisation’s operations (Global Reporting Initiative, 2012). The GRI guidelines were developed in 2000 and have been through four revisions. The G4, the most

recent revision of the GRI, provides offers reporting principles, standard disclosures and an implementation manual to assist organisations to prepare sustainability reports.

A Boston College Center for Corporate Citizenship and Ernst & Young (2013) report investigated the value provided by sustainability reporting as well as the different reporting standards used by organisations. The report found that 51% of the organisations surveyed complied strictly with the guidelines outlined by the GRI. Of the organisations included in the survey, 18% indicated that they used some of the GRI guidelines or a variation thereof. Of the remaining organisations, 18% were not sure what guidelines they were following, 6% had no reporting framework, and 4% used guidelines not related to the GRI guidelines.

The GRI provides a standard for organisations to measure performance against. The guidelines also provide organisations with the ability to benchmark performance and to measure performance against similar organisations (Global Reporting Initiative, 2012). The GRI is designed to meet the information requirements of multiple stakeholders. The GRI guidelines are founded on the principles of transparency, inclusiveness and stakeholder engagement, audibility, completeness, relevance, accuracy, comparability, clarity and timeliness. The report is subdivided into several key sections. These sections are: vision and strategy, organisational profile, governance structure and management systems, GRI context and performance indicators (Herremans and Herschovis, 2006).

The GRI guidelines are currently the most comprehensive and globally accepted standard for sustainability reporting (Lozano, 2011). Lozano (2011) does caution against adopting these guidelines in higher education as they were developed for standard business enterprises and not HEIs. Lozano (2011) has developed modified GRI guidelines that are better suited for higher education (Table 3-1).

Table 3-1: The modified GRI for higher education (Lozano, 2011)

Category	Aspect
ECONOMIC	
Direct economic impact	Customers, suppliers, employees, providers of capital, public sector
EVIRONMENTAL	
Environmental impact	Materials, energy, water, biodiversity, emissions, effluents and waste, suppliers, products and services, compliance, transport, overall
SOCIAL	
Labour practices and decent work	Employment, labour/management relations, health and safety, training and education, diversity and opportunity, strategy and management
Human rights	Non-discrimination, freedom of association and collective bargaining, child labour, forced and compulsory labour, disciplinary practices, security practices, Indigenous rights
Society	Community, bribery and corruption, political contributions, competition and pricing
Product responsibility	Customer health and safety, products and services, advertising, respect for privacy
EDUCATIONAL	
Curriculum	Sustainable Development (SD) incorporation into curriculum, SD capacity building, SD monitoring in curricula, administrative support
Research	Research in general, grants, publications and products, programmes and centres
Service	Service learning

The modified GRI guidelines developed by Lozano (2011) include the economic, environmental and social aspects, which are the three standard aspects of sustainability as identified by the triple bottom line (Elkington, 1994). The difference between the standard GRI guidelines and modified GRI guidelines for higher education is the addition of an educational category (Figure 3-7).

A need exists for all organisations, including HEIs, to produce sustainability reports that cover all aspects of the organisation's operations. HEIs are encouraged to report on financial/economic data (income and expenditure), social data (enrolments), environmental data (environmental impacts) and educational data (teaching and learning, and research) (Merkel and Litten, 2007). Although the modified GRI guidelines proposed by Lozano (2011) are better suited to HEIs than the standard guidelines, they have not yet been adopted as official

guidelines by the GRI. This could be a key factor driving the increased adoption of STARS by HEIs globally.

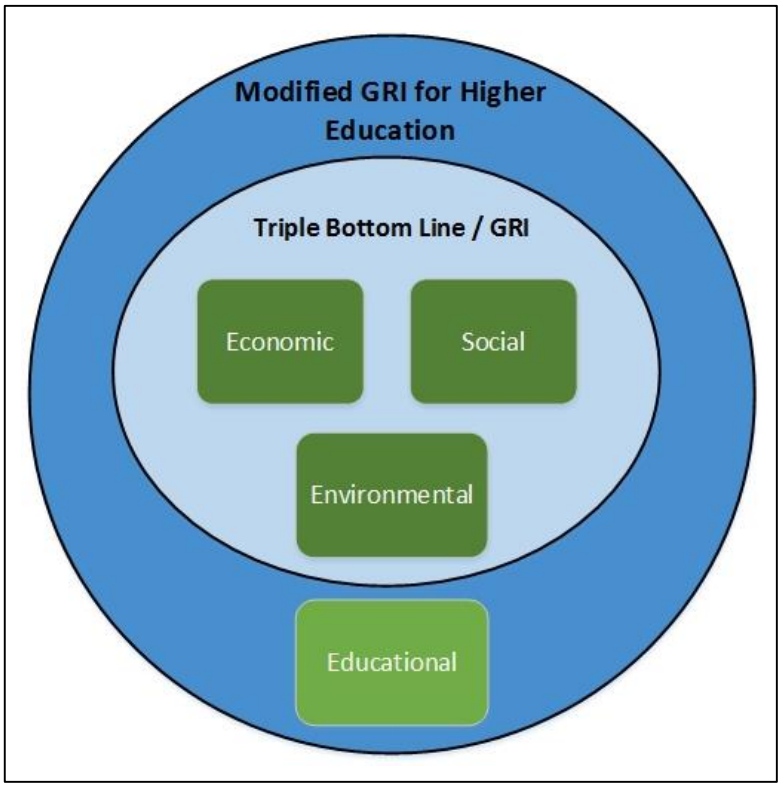

Figure 3-7: GRI components (Author's own construct)

3.5.1.2 Sustainability Tracking, Assessment and Rating System (STARS)

The Sustainability Tracking, Assessment and Rating System (STARS) is a sustainability assessment standard developed by the Association for the Advancement of Sustainability in Higher Education (AASHE) in 2006 (Shi and Lai, 2013). STARS is a standard that was developed with the purpose of providing a platform for HEIs to gauge their progress towards sustainability. STARS was developed with the intention of broad participation from HEIs in the USA and Canada (Association for the Advancement of Sustainability in Higher Education, 2011).

The goals of STARS are to (Shi and Lai, 2013):

- develop standards to better understand sustainability in higher education;
- create a set of common measures that enables comparison between multiple HEIs;

- provide standards for HEIs to measure and report on all relevant areas of sustainability including higher education specific areas including the including curriculum, research, operations, administration and engagement;
- develop a campus sustainability community in HEIs; and
- recognise continual improvement in sustainability practices by providing incentives.

STARS participants need to register with the AASHE in order to qualify for a STARS rating. Participants pursue credits in order to obtain a Platinum, Gold, Silver or Bronze rating. The credits cover the entire spectrum of sustainability in HEIs and are subdivided into four separate categories:

1. Planning and Administration;
2. Academics;
3. Engagement; and
4. Operations.

Each category contains a number of subcategories in which an institution can obtain credits (Table 3-2). A more detailed list, including all the credits for each subcategory, is provided in Appendix A. The subcategories are explained in greater detail in the STARS technical manual.

Table 3-2: STARS credit groupings (Association for the Advancement of Sustainability in Higher Education, 2011)

Academics (AC)	Engagement (EN)	Operations (OP)	Planning & Administration (PA)
• Curriculum • Research	• Campus Engagement • Public Engagement	• Air & climate • Buildings • Dining Services • Energy • Grounds • Purchasing • Transportation • Waste • Water	• Coordination, Planning & governance • Diversity & Affordability • Health, Wellbeing & work • Investment

The number of credits available in each category differs. The Operations category has the highest weighting with 33% of the credits issued to this category. This is followed by the

Academics category, the core function of HEIs, with 29%. The Engagement and Planning and Administration categories have a weighting of 21% and 17% respectively.

No institution has become a Platinum member yet which requires a points rating of between 85 and 100 points. Of the STARS-compliant institutions, 18% are Gold rated which requires a points rating of between 65 and 84 points. Half of the STARS registered institutions have a Silver rating which requires a point's total of between 45 and 64 points. Institutions with a Bronze rating make up 25% of the STARS registered universities. A Bronze rating requires a point's score of between 25 and 44 points. The final category is the reporter category in which institutions do not publically disclose their scores. The remaining 7% of STARS registered institutions have Reporter status.

Only a limited number of STARS-compliant institutions exist in Europe and Asia. The majority of STARS-compliant universities are based in North America because the system was originally developed for North American institutions and a large number of the STARS credits are not relevant to institutions outside North America (Association for the Advancement of Sustainability in Higher Education, 2011). There was growing interest in the STARS rating system globally however, which led to the development of the STARS international pilot program. AASHE developed the international pilot to provide institutions with the opportunity of reporting their sustainability efforts. The pilot will also enable AASHE to gain a better understanding of the sustainability requirements globally, and make improvements to the standards based on feedback received from participating institutions.

3.5.1.3 Sustainability Data Landscape in HEIs

An analysis of existing reporting standards and frameworks has revealed that four aspects of sustainability should be covered by HEIs. The GRI for Higher Education refers to these four aspects as economic, social, environmental and educational (Lozano, 2011). Whilst STARS refers to these categories as Academics, Engagement, Operations, and Planning and Administration, these categories cover the same four broad categories of sustainability covered by the GRI for higher education.

It is evident that data is required from all four aspects of sustainability. Therefore, a sustainability data landscape is proposed, which provides a mapping of the GRI for Higher Education components mapped to the STARS components, as well as the relevant generic data

sources for each sustainability component (Figure 3-8). The sustainability data landscape builds on Sayed and Asmuss's (2013) model (Figure 3-3), by including a mapping of GRI and STARS components as well as the sustainability data sources. The data sources are generic data sources used to highlight how the sustainability information for the different sustainability components are often stored in disparate data sources.

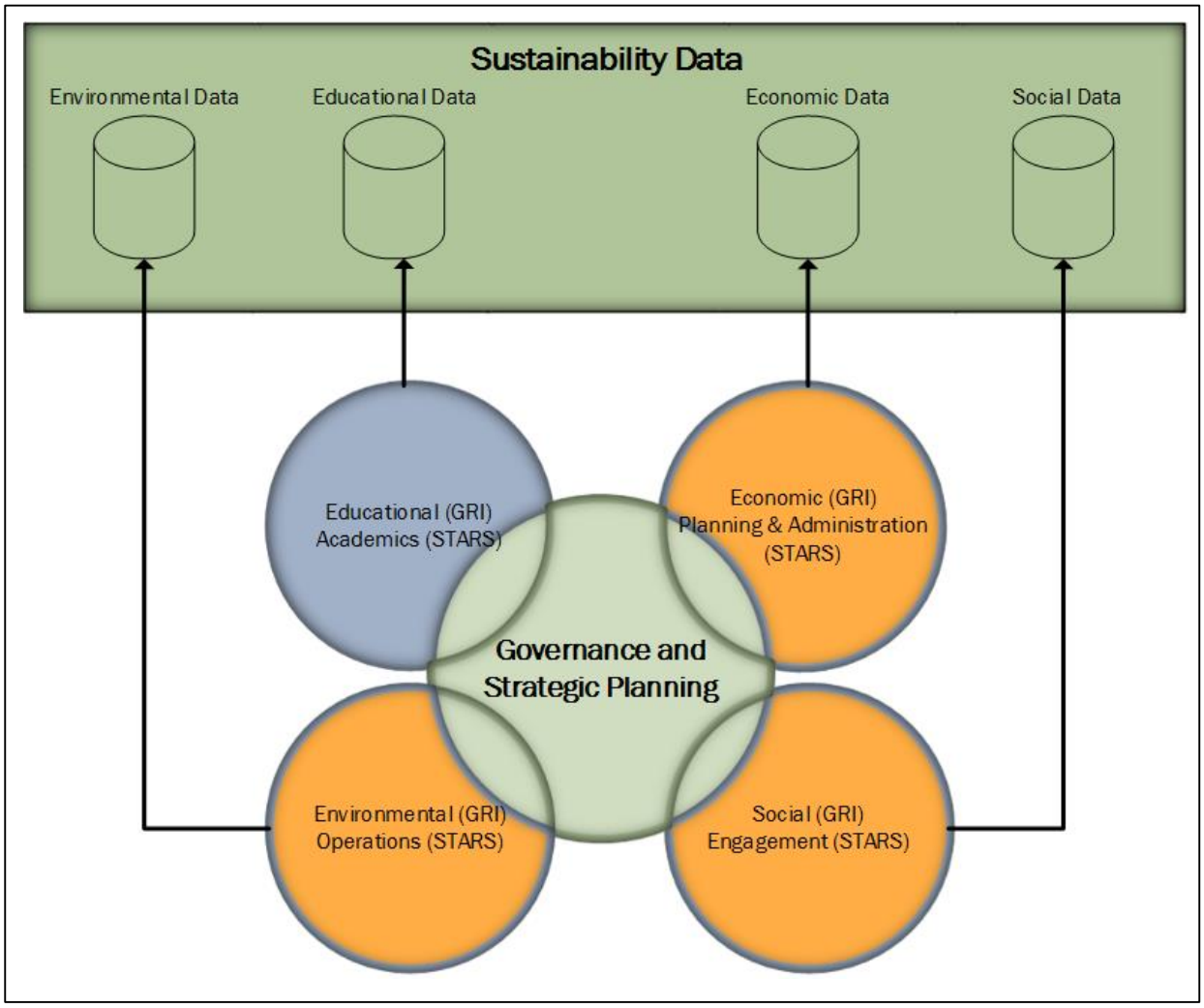

Figure 3-8: Sustainability data landscape for HEIs (Author's own construct)

The sustainability data landscape illustrates how sustainability data is sourced from multiple data sources. These data sources should include educational data sources, social data sources, environmental data sources and economic data sources. When applied to an actual organisation, the four sustainability data sources could be broken down further, for example, there could be a teaching and learning database as well as a research database, which would both fall under education. Whilst the sustainability data can be contained within multiple data sources, the data sources should be made available across the entire organisation and not just siloed in one

functional area or department. By making these data sources available organisation-wide, decision-making can be improved as decision-making will no longer be siloed in nature.

3.6 Sustainability Reporting in South African Higher Education

A study conducted by Bosire (2014) aimed to gain a better understanding on the reporting practices of HEIs. As part of his research, Bosire (2014) conducted a survey with all 23 of South Africa's public universities, in which university registrars were required to indicate the make-up of their reports. The registrars are involved in the strategic management of the institution and thus the survey provides an accurate reflection of strategic reporting in South African HEIs. The study found that that at a strategic level in South African HEIs, the main focus of reporting is still the financial aspect. The survey found that at the strategic level reports consist of 70% economic data, 20% social data and only 10% environmental data. This indicates that sustainability reporting has not yet been embraced at the strategic level of South African HEIs.

Because the study found that sustainability reporting has not yet been embraced at the strategic level of South African HEIs, Bosire (2014) also looked at the factors affecting the introduction of sustainability reporting in South African HEIs. It was found that there are several factors causing the slow adoption of sustainability reporting practices in South African HEIs, namely:

- the voluntary nature of sustainability reporting;
- the lack of higher education reporting standards;
- the lack of comparability; and
- the lack of standards to audit sustainability reports.

These factors indicate that the lack of regulatory requirements enforcing sustainability reporting play a major role in the slow adoption of sustainability reporting, which confirmed the study of Adams (2002). The study also found that the lack of training of management also played an important role in the slow adoption of sustainability reporting. Training is an important aspect when introducing change into an organisation. It was found that management had received little training in areas such as understanding the concept of sustainability reporting and its importance to the institution, the use of BI tools in the sustainability reporting process, developing metrics for sustainability reports and the use of BI reporting tools such as dashboards and scorecards to present sustainability data. The introduction of sustainability

reporting in any sector requires an organisation to have well established and effective data acquisition and management processes (Fonseca, Macdonald, Dandy and Valenti, 2011; Lozano, 2006). The higher education sector in South Africa does not currently have well established and effective data acquisition and management processes in place (Bosire, 2014; Jonamu, 2014). In an attempt to overcome this problem, Jonamu (2014) conducted a study to improve these existing processes.

3.7 Software Tools for Sustainability Reporting

Whilst some organisations do not have tools dedicated specifically to sustainability reporting, many software tools are available that are dedicated to helping an organisation produce sustainability reports (Pina, 2011). Figure 3-9 highlights the sustainability reporting maturity levels (KPMG, 2012). At the lowest level of the maturity spectrum is the use of office software for sustainability reporting. Many organisations begin their sustainability reporting efforts by using a tool such as Microsoft Excel to generate reports (KPMG, 2012). Organisations use these tools because they are easily accessible, cheap and familiar to business users (Scholtz, Connolley and Calitz, 2014). There are several limitations with using such tools, with the biggest limitation being the maintainability and integrity of the data as the scope of sustainability reporting grows within the organisation.

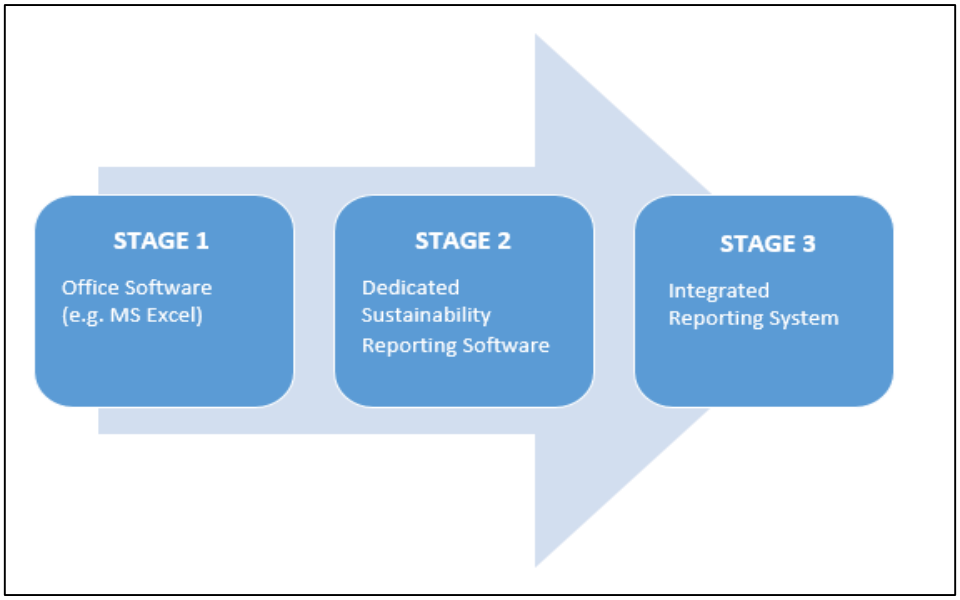

Figure 3-9: Sustainability reporting maturity model (KPMG 2012)

At stage two of the sustainability reporting maturity spectrum, in which organisations are at a medium maturity level, dedicated sustainability reporting software is used to report on the

organisation's sustainability efforts. Pina (2011) investigated a range of dedicated sustainability reporting software tools (Table 3-3).

Table 3-3: Dedicated sustainability reporting tools [adapted from (Pina, 2011)

Vendor	Tool/Application/Suite	Model	Functions	Reporting
GRI Standards				
Credit 360	Credit360 modules: Energy & Carbon, EHS, CSR, Compliance	Cloud-based service. Subscription	Data collection, tracking, managing, reporting, communication. Support and training.	GHG, GRI. CDP certified.
Enablon	SD-CSR (Sustainable Development – Corporate Social Responsibility) GHG-MS	Cloud-based service or on-premises software.	Sustainability data collection, consolidation, reporting, management. Mature.	GRI, CDP certified
We Sustain	We Sustain Enterprise Sustainability	Cloud-based Service	Central data collection. Communication and reporting through dashboards.	GRI, SAM-DJSI, CDP
Microsoft	Environmental Sustainability Dashboard for Dynamics AX	Requires Dynamics AX ERP suite. Licence software.	Energy consumption & GHG emissions tracking.	Based on GRI
Other Standards				
Verisae	Hara	Cloud-based service.	Energy consumption ,GHG emissions tracking and resource use.	GHG
Oracle	Oracle Environmental Accounting and Reporting	Requires Oracle E-Business Suite 12.1+. Licenced software.	Automated and manual environmental data collection (mainly GHG emissions); tracking; compliance; reporting; opportunities.	GHG, CDP
Sustainable IT	The Carbon Report http://www.sustainableit.co.za/sample-page/carbon-footprint-software/	Cloud-based service. Annual subscription.	GHG only. Purports to make data gathering and reporting simple. Consultant support (verification & review) and training.	GHG Protocol
Greenstone	Acco2unt	Cloud-based service. Annual subscription.	Carbon accounting. Focus on aggregation and reporting. Expert support	Various including CDP, GHG
Enviance	Environmental ERP	Cloud-based service. Includes mobile solutions. Subscription.	Measure, manage and report GHG emissions, environmental, health and safety (EHS) data, and other environmental information	US EPA GHG rule

The final stage of the sustainability reporting maturity model focusses on organisations making use of integrated reporting tools to report on their sustainability efforts. However these tools do not only provide sustainability reporting capabilities, but also enable sustainability reporting to be integrated with additional reports and business operations.

3.8 Constraints to Effective Sustainability Management

Research has highlighted the need to have both effective corporate sustainability initiatives (Schaltegger and Wagner, 2006) and corporate information systems (ISs) to address sustainability and effectively manage sustainability information (Epstein and Wisner, 2001). In order to effectively manage sustainability information and sustainability initiatives HEIs need to align their sustainability strategy with their IS strategy (Melville and Whisnant, 2012; Pearlson and Saunders, 2010). The misalignment of the sustainability strategy and the IS strategy hinders the achievement of sustainability objectives and can lead to information not being available to the right people at the right time (Hoffman, 2010; Scholtz et al., 2014). The misalignment of sustainability strategies and IS strategies in many organisations is highlighted by the absence of an integrated IS for managing sustainability information (Melville and Whisnant, 2012; Pearlson and Saunders, 2010).

One of the biggest challenges organisations face with managing sustainability is the collection, integration and reporting of sustainability information (Frost, Jones and Lee, 2012). Many organisations still make use of manual reporting systems, such as spreadsheets, to manage sustainability information. Many IS that were developed to assist in sustainability management have only focussed on a certain aspect of sustainability, such as Environmental Management Systems (EMSs) (Disterheft et al., 2012; Nicolaides, 2006; Sammalisto and Lindhqvist, 2005).

While the trend of movement towards sustainable HEIs continues to gain momentum, many HEIs do not consider an integrated IS at the early stage of sustainability transformation (Goni et al., 2013). There are many constraints to effective sustainability information management such as:

- lack of sustainability data access (Bosire, 2014; Velazquez et al., 2005);
- unavailability of data (Jonamu, 2014; Munguıa, 2002; Shapiro, 2014);
- overlapping of data (Goni et al., 2013; Herremans and Allwright, 2000);
- siloed decision-making (Goni et al., 2013);

- siloed data and information (Herremans and Allwright, 2000); and
- poor sharing and communication of information (Goni et al., 2013).

One of the key factors affecting the effective management of sustainability in HEIs is the lack of sustainability data access (Bosire, 2014; Velazquez et al., 2005). Data related to water and electricity usage is often inaccurate as it has to be estimated as there meters are often inaccurate or meters are not accessible (Jonamu, 2014; Munguıa, 2002). HEIs often have many disparate ISs which leads to decision makers being unable to obtain all sustainability data as data is siloed across different ISs. Siloed information often results in sustainability efforts being overlapped between departments (Herremans and Allwright, 2000), as well as the same data being recorded by multiple departments. This can cause an overlapping of data when the data is integrated (Goni et al., 2013).

Whilst this study will focus on overcoming the shortcomings related to the information component of strategic sustainability management, there are other constraints to effective sustainability management in HEIs that relate to management and people issues in an organisation. These constraints are:

- lack of awareness, interest and involvement in sustainability initiatives (Velazquez et al., 2005);
- lack of funding (Velazquez et al., 2005);
- lack of support from university administrators (Orr, 2000; Velazquez et al., 2005);
- poor regulatory control (Bosire, 2014; Estevez, 2002; Velazquez et al., 2005);
- lack of performance indicators (Velazquez et al., 2005); and
- lack of policies to promote sustainability on campus (Wright, 2004).

People in charge of sustainability initiatives often complain about the lack of interest and awareness from a large portion of the university community (Velazquez et al., 2005). Those in charge of sustainability initiatives are often academics with other primary responsibilities, which results in limited time to focus on sustainability initiatives (Orr, 2000; Velazquez et al., 2005). The existence of policies for supporting sustainability efforts is very limited in HEIs, and when these policies do exist they are often poorly enforced (Wright, 2004). Table 3-4 provides a summary of the factors obstructing effective sustainability management.

Table 3-4: Constraints to effective sustainability management

Constraint to effective sustainability management	Author
INFORMATION AND IS	
Lack of sustainability data access	Bosire (2014); Velazquez et al. (2005)
Unavailability of data	Bosire (2014); Munguıa (2002)
Overlapping of data	Goni et al. (2013)
Siloed decision-making	Herremans and Allwright (2000)
Siloed data and information	Herremans and Allwright (2000); Roturier and De Almeida (2000)
Poor sharing and communication of information	Velazquez et al. (2005)
MANAGEMENT AND PEOPLE	
Lack of awareness, interest and involvement in sustainability initiatives	Velazquez et al. (2005)
Lack of funding	Velazquez et al. (2005)
Lack of support from university administrators	Velazquez et al. (2005)
Poor regulatory control	Bosire (2014); Estevez (2002); Velazquez et al. (2005)
Lack of performance indicators	Velazquez et al. (2005)
Lack of policies to promote sustainability on campus	Wright (2004)

3.9 Sustainability Management Model (Version1)

An initial theoretical model for sustainability management is proposed based on the drivers of sustainability awareness and initiatives (Figure 3-4), as well as the constraints to effective sustainability management (Table 3-4). The model can assist an organisation determine the need for understanding the purpose of effectively managing sustainability initiatives, as well as the challenges that need to be overcome (Figure 3-10).

Whilst there are many factors driving sustainability initiatives in HEIs, there are still many factors hindering effective sustainability management in HEIs. The purpose of this study is to find a solution to more effectively manage strategic sustainability information in HEIs. The

proposed solution will therefore only focus on overcoming the information and IS constraints, highlighted in blue in Figure 3-10.

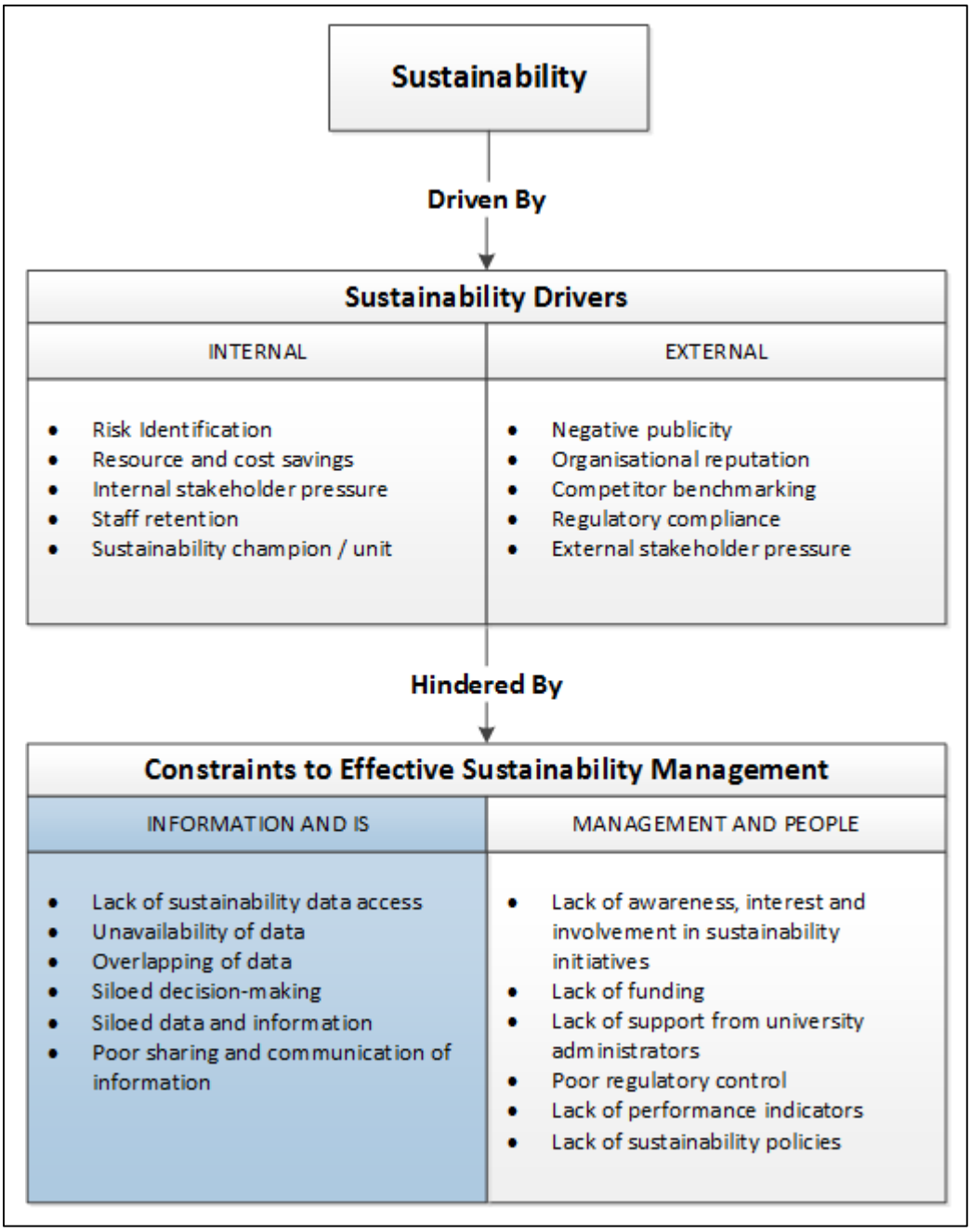

Figure 3-10: Sustainability Management Model (Version 1) (Author's own construct)

3.10 Strategic Sustainability Management at NMMU

NMMU is a comprehensive public university, constituted of seven faculties located across six campuses across South Africa, five in Port Elizabeth (Eastern Cape) and one in George (Western Cape) (Nelson Mandela Metropolitan University, 2014). NMMU has a student

complement that averages between 25 000 and 26 000 and an average permanent staff complement of 1 699. NMMU is predominantly a non-residential university, with only 1 417 (6%) students living in university residences in 2014, with the majority of students commuting to university. Eighty percent of NMMU students hail from the largely rural Eastern Cape Province, which is South Africa's poorest province with the poorest matric pass rate.

Sustainability is a key strategic priority at NMMU (Section 1.1). This is highlighted by its vision to be *"a dynamic African university recognised for leadership in generating cutting-edge knowledge for a sustainable future"* and its mission *"To offer a diverse range of quality educational opportunities that will make a critical and constructive contribution to regional, national and global sustainability."* (Nelson Mandela Metropolitan University, 2008, p. V)

The importance placed on sustainability is also highlighted by the NMMU Vision 2020 Strategic Plan (referred to as Vision 2020). The plan outlined the purpose of the institution and the institution's long-term vision. The plan outlines a number of strategic priorities that will secure the long-term sustainability of the institution. Sustainability is a key theme identified throughout Vision 2020, highlighting NMMU's commitment to promoting a sustainable future. The incorporation of sustainability into the organisational strategy is a key factor in ensuring that sustainability initiatives receive the necessary attention (Section 3.2). By incorporating sustainability into its strategy, sustainability will need to be managed and monitored effectively. Therefore, NMMU provides the ideal case study for this research. At NMMU, many of the issues related to the strategic sustainability management centre around the management of the data and the lack of tools available to analyse the data.

The relationship between good governance and an institution's sustainability strategy (Section 3.2), is again highlighted by the NMMU governance monitoring, evaluation and reporting framework (Figure 3-11) (NMMU, 2012). The main purpose of the governance monitoring, evaluation and reporting framework developed by NMMU is to facilitate efforts in monitoring and reporting on the strategic priorities identified in Vision 2020. NMMU's commitment to sustainability is highlighted by this framework, as NMMU has integrated sustainability principles into its policy and organisational praxis.

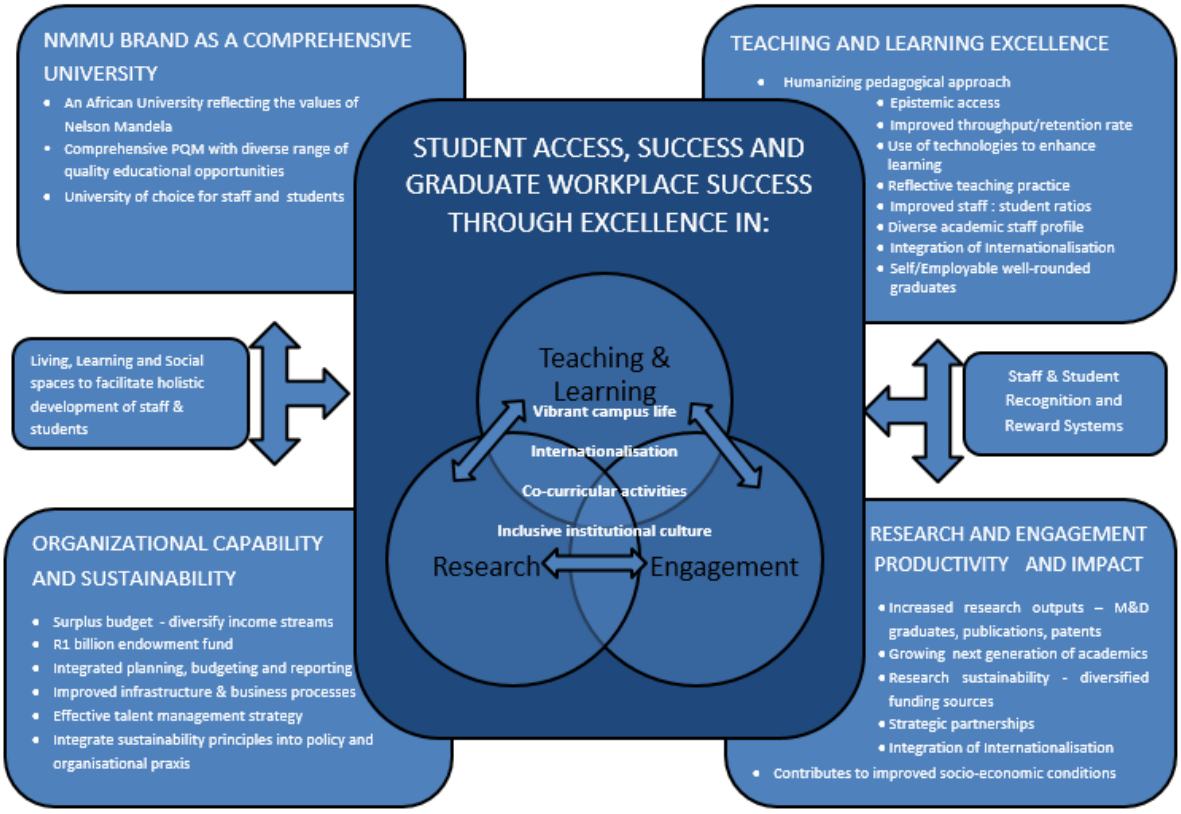

Figure 3-11: NMMU governance monitoring, evaluation and reporting framework (Nelson Mandela Metropolitan University, 2012).

3.10.1 Sustainability Reporting at NMMU

NMMU, as a public South African HEI, is required to comply with the new reporting regulations outlined by the DHET (DHET 2014). One such report outlined in the new regulations is the Report of the Chairperson of Council. The Report of the Chairperson of Council is "*an integrated report that conveys adequate information about the operations of a public higher education institution, its sustainability and financial reporting. It should include a performance review encompassing economic, social and environmental aspects and should not confine itself to past issues but should provide forward-looking information to place the reported results and performance in context and to show transparency.*" (Department of Higher Education and Training, 2014, p. 16)

Whilst sustainability reporting provides a platform to monitor and disclose sustainability efforts, the reporting is only produced on a periodic basis and therefor does not enable up-to-date monitoring and management of sustainability issues. This is no different at NMMU, where members of NMMU's Manco are responsible for different portfolios at the institution

(Levendal, 2015). Each of these Manco members provides a periodic report, usually every quarter, to the vice-chancellor, from which he compiles a single integrated report (Figure 3-12).

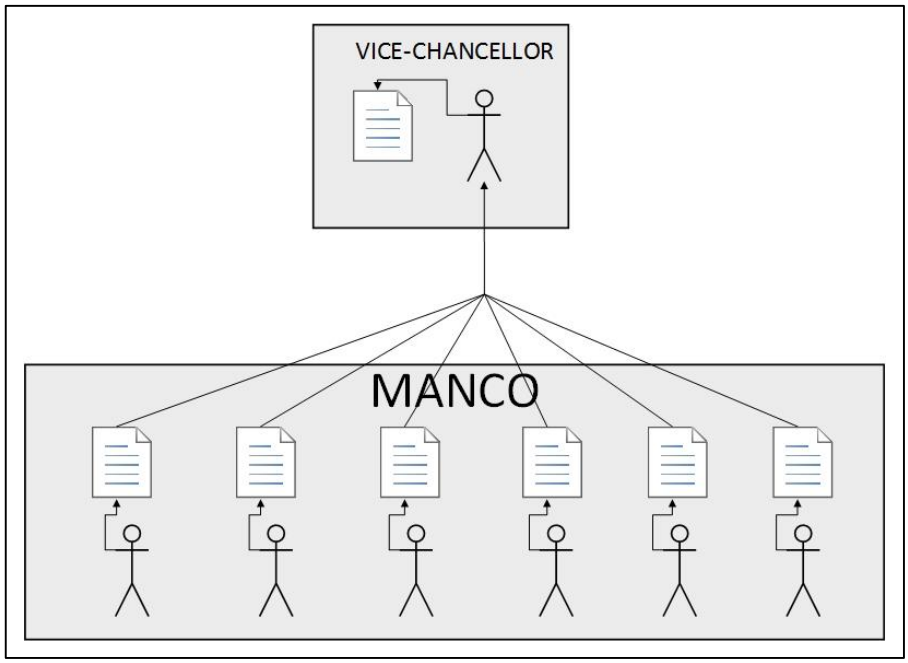

Figure 3-12: NMMU reporting process (Author's own construct)

The reporting process at NMMU highlights the problem of the siloed nature of sustainability information, evidenced by the disparate information management systems, such as BI systems, used throughout NMMU (Van Leeve, 2015). Each department works off different operational data stores and then develops its own information management system around those data stores. The NMMU data landscape drafted by the researcher also highlights the siloed approach to the management of information at NMMU (Figure 3-13). The NMMU data landscape applies the sustainability data landscape (Figure 3-8), to the case of NMMU. The different components of sustainability information are stored in different formats across multiple departments. The sustainability data is often not shared between the different departments, again emphasising the silo effect at work. The current data landscape at NMMU is not desirable as it does not allow for the integration of information, therefore leading to siloed decision-making.

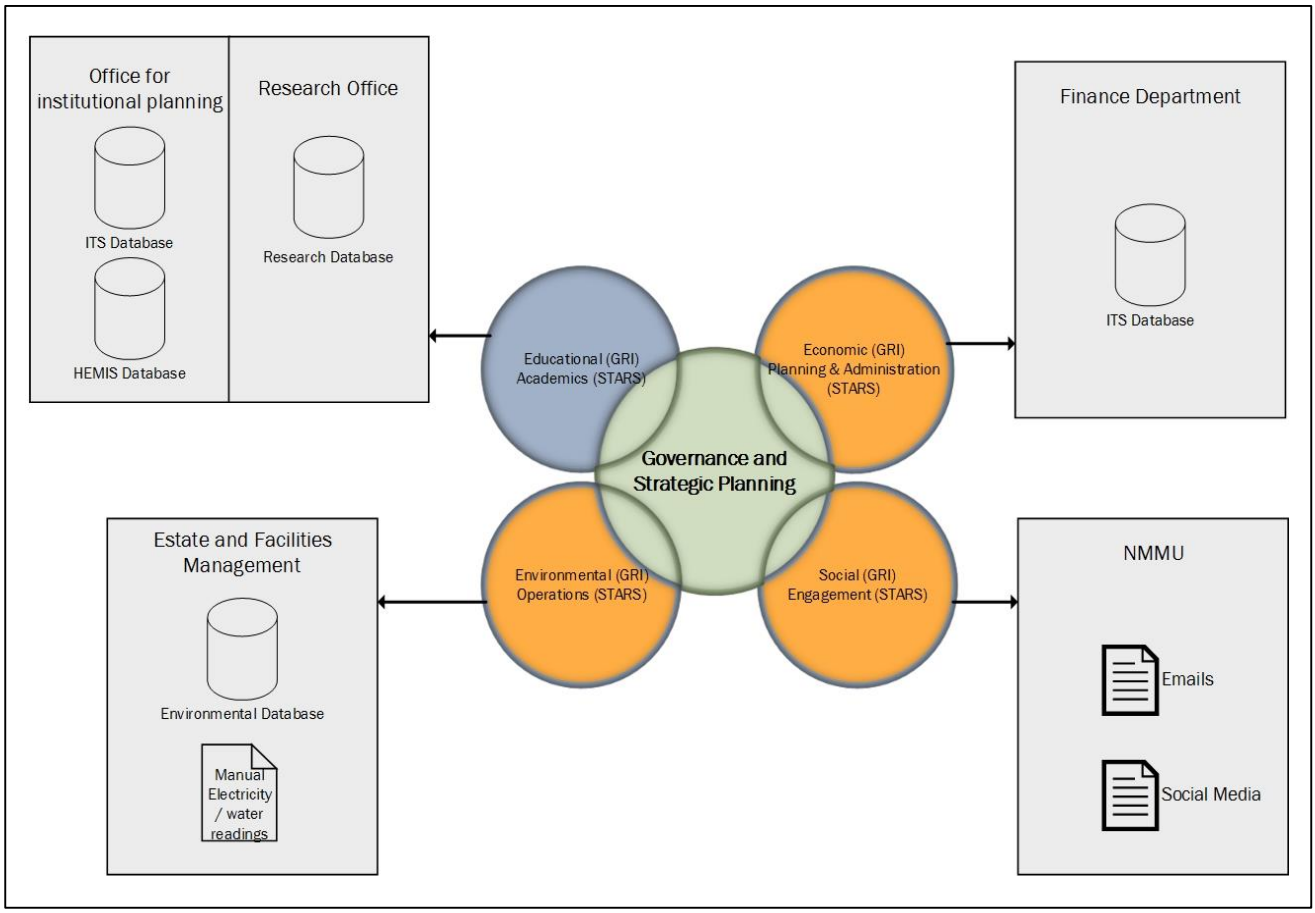

Figure 3-13: NMMU data landscape for sustainability data (Author's own construct)

Each department at NMMU has developed its own IS to cater for its own specific needs. Each department has a mandate and therefore focuses entirely on that mandate (Levendal, 2015; Van Leeve, 2015). The large size of NMMU makes it impossible to focus on all the disparate data stores and ISs throughout the institution, therefore the Office for Institutional Planning was selected for further investigation. A closer look at the data landscape used by the Office for Institutional Planning highlights how data warehouses and data cubes have been developed based on their own mandate (Figure 3-14) (Van Leeve, 2015).

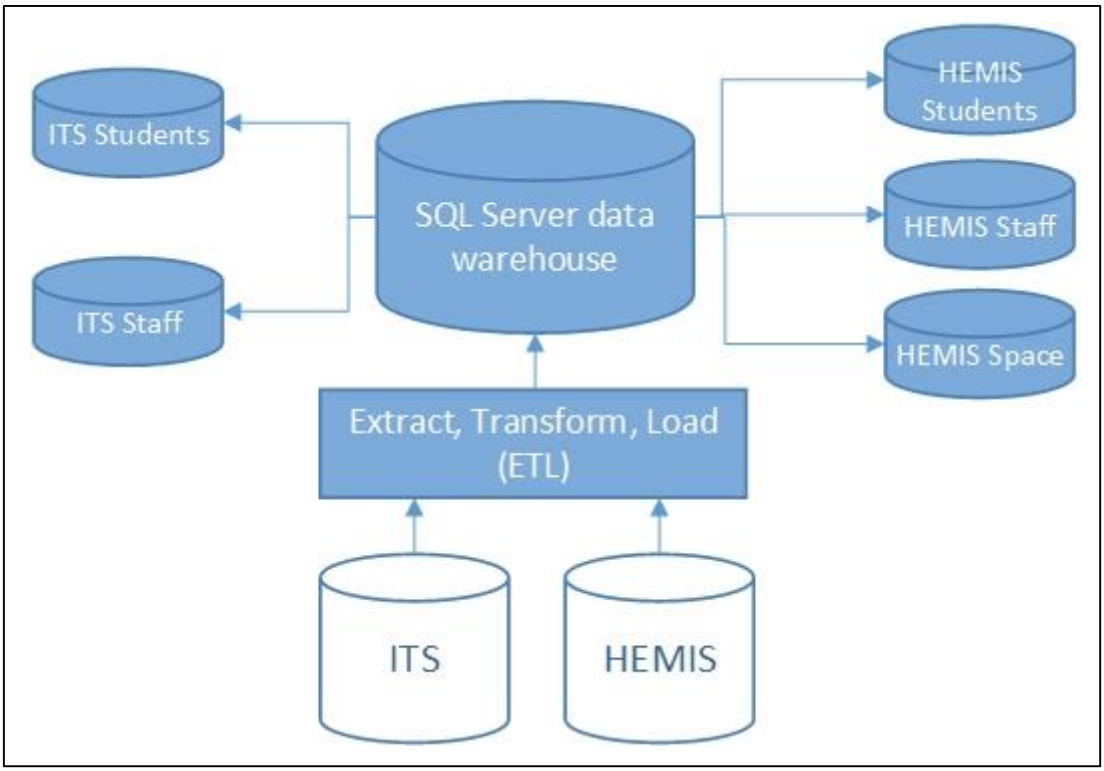

Figure 3-14: Office for Institutional Planning data landscape (Van Leeve, 2015)

The landscape makes use of two operational data stores, the ITS database and the HEMIS database. The ITS and HEMIS databases are both responsible for storing educational data. The ITS database stores current, operational data whereas the HEMIS database stores historic data. A SQL Server data warehouse has been developed to integrate the data from the ITS and HEMIS databases. The data goes through an extract, transform and load (ETL) process in which the data is extracted from the operational data stores, cleaned and transformed into the required format of the data warehouse and then loaded into the data warehouse. Five data cubes have been created from the data warehouse, the ITS students cube, the ITS staff cube, the HEMIS students cube, the HEMIS staff cube and the HEMIS space cube.

3.10.2 Economic Sustainability

One of the four components of sustainability for HEIs, identified by Lozano (2006), is the financial/economic component. The importance of economic sustainability at NMMU is highlighted by strategic priority six in Vision 2020. Strategic priority six is to "*Formulate and implement a financial growth and development strategy to enhance long-term sustainability and competitiveness.*" As part of this priority NMMU wishes to achieve a financial position that reflects a healthy balance sheet in which there are sufficient reserves, a positive cash flow

and the generation of a R1 billion endowment fund (Nelson Mandela Metropolitan University, 2008). The Finance Department at NMMU is largely responsible for this area of sustainability.

In order to achieve its goal of financial sustainability, NMMU has developed a Financial Growth and Development Plan (FGDP) (Nelson Mandela Metropolitan University, 2013). The FGDP will become an integral part of the NMMU's strategic plan, highlighting the importance which NMMU places on long-term financial sustainability. The long-term financial sustainability of the institution is somewhat related to the education component of sustainability. A large proportion of a South African HEIs revenue is based on the research output of the institution (Bosire, 2014). The financial goals of NMMU, as well as indicators for each of these goals, are listed in Table 3-5.

Table 3-5: Financial sustainability goals and indicators at NMMU

GOAL	Develop an integrated long-term financial plan that is responsive to institutional strategic priorities and promotes sustainable growth	Grow and diversify income streams to support the attainment of the institutional strategic goals	Ensure efficient and effective utilisation of institutional assets and resources (academic, HR, financial, infrastructural) to enhance long-term financial viability
INDICATORS	➢ EMCOM approved % strategic resource allocation from available resources ➢ x% of surplus to general reserve	➢ Change in net income from fees & subsidy per FTE ➢ % Increase year x + 1 on year x ➢ % improvement of success rate ➢ % non-viable modules to total modules	➢ Change in net income from fees & subsidy per FTE ➢ % of endowment fund target raised ➢ % expenditure on shuttle service

3.10.3 Environmental Sustainability

The environmental aspect is one of the three primary aspects of sustainability. Jonamu (2014) developed an Environmental Management Information System (EMIS) at NMMU to assist the university to manage this aspect of sustainability. Because HEIs are often diverse in nature, the environmental indicators associated with these HEIs are also diverse. This is a point that has also been highlighted by STARS. Jonamu (2014) provides a list of common environmental

indicators in HEIs, including NMMU (Table 3-6). These indicators are grouped into six separate categories:

1. utilities usage;
2. transportation and commuting;
3. waste generation;
4. educational programmes;
5. grounds/natural heritage; and
6. purchasing/food services.

Within each of these categories are a number of indicators. Indicators include energy consumption, renewable energy use, air travel, electronic waste and recycling. Table 3-6 provides a summary of the categories as well as some of the indicators within each category.

Table 3-6: Environmental indicators at NMMU

Category	Indicator
Utilities Usage	Energy consumption
	Renewable energy
Transportation and Commuting	Air travel
	Campus vehicle fleet fuel use
Waste Generation	Electronic waste
	Recycling
Educational Programmes	Environmentally related programmes to study
	Environmentally related research projects
Grounds/Natural Heritage	Pesticide/herbicide fertiliser use
Purchasing/Food Services	Janitorial products
	Recycled paper and materials

3.10.4 Social Sustainability

The fundamental purpose of any HEI is to serve the public through knowledge production and the provision of skilled graduates that assist in advancing socio-economic development (Nelson Mandela Metropolitan University, 2013). At NMMU this fundamental purpose is pursued by both staff and students through various engagement projects. These projects take the form of community interaction, service and outreach, teaching and learning and/or research scholarship. There are many examples of engagement (social sustainability) projects that have been undertaken by NMMU. The institution has increased the number of short learning and

customised skills training programmes that target the needs of business and industry. One of the social sustainability goals of NMMU is to produce graduates that are well-rounded and responsible citizens. The development of the Beyond the Classroom Programme is one step closer towards achieving social sustainability goals.

3.10.5 Educational Sustainability

Educational sustainability is an aspect of sustainability that is only relevant to HEIs and not to traditional organisations. Education is the core operation of any HEI and includes teaching and learning and research. The first strategic priority outlined in Vision 2020 is to "*Establish a distinctive academic brand and educational philosophy at NMMU that promotes critical scholarship and develops well-rounded and responsible graduates capable of success as citizens in the global knowledge society.*" Strategic priority three in Vision 2020 is to "*Create and sustain an environment that encourages, supports and rewards a vibrant research, scholarship and innovation culture.*" The focus of these two strategic priorities is on making the NMMU curriculum as sustainable as possible (Nelson Mandela Metropolitan University, 2008). Within each of the identified strategic priorities are a number of goals and indicators (Figure 3-7).

Table 3-7: Educational sustainability goals and indicators

Goal	Determine the academic size and shape of NMMU in a manner that optimises our strategic niche as a comprehensive university and responds to regional, national and global development needs	Design and implement a range of access routes as well as progression and articulation strategies and pathways between qualification types to enhance student access and progression	Conduct research that contributes to local, regional, national and global sustainability
Indicators	➢ Ratio of applicants : admissions : registrationsx ➢ % of surplus to general reserve ➢ Student FTE enrolments by programme/qualification on each campus compared to HEMIS space utilisation norms ➢ No. of students who have APS >=44 ➢ Turnaround time from point of application to admission response	➢ Success rates of extended programme students ➢ Number of FET learners enrolling at NMMU% improvement of success rate ➢ Number of NMMU enrolled students who participated in access programmes	➢ No. of Research Centres of Excellence ➢ No. of Research Chairs ➢ No. of commercialised research products

3.11 Supporting Strategic Sustainability Management Using IS

Various studies have highlighted the importance that a dedicated sustainability IS plays in addressing sustainability issues (Jenkin, Webster and McShane, 2011). However, there is limited research that has examined the role that an IS plays in collecting, integrating and reporting the sustainability data and information (Disterheft et al., 2012; Nicolaides, 2006; Sammalisto and Lindhqvist, 2005). In practice, ISs, to support sustainability information management has focussed primarily on only a single component of sustainability, such as Environmental Management Information Systems (EMIS).

Studies have suggested that Business Intelligence (BI) is an appropriate technology that can assist in the management of sustainability information. BI is a component of the underlying infrastructure that enables effective sustainability management (Bosire, 2014). BI is a set of methodologies, processes, architectures and technologies that assist in transforming raw data into meaningful information to enable more effective strategic, tactical and operational decision-making (Evelson, 2008; Sharman, 2010). BI can also be viewed as the product of the knowledge creation process (Sabherwal and Becerra-Fernandez, 2011). BI allows management to gain better insight into performance, by enabling the integration of information within existing systems with the goal of presenting a single set of easy-to-understand graphical visualisations (Stocker, 2010).

A wide range of definitions exists for BI, with different authors providing differing opinions on what exactly BI is. There is no one globally accepted definition for BI. Sabherwal and Becerra-Fernandez (2011) define BI in two distinct ways. BI can refer to the process by which an organisation collects, analyses and distributes information and knowledge. BI can also be viewed as the product of the process of collection, analysis and distribution. The product of this process can be used in the decision-making process and other business activities. The definition provided by Davenport (2010) is somewhat of a middle-ground of the two definitions provided by Sabherwal and Becerra-Fernandez (2011). Davenport (2010, p.3) defines BI as *"the skills, processes, technologies, applications and practices used to support decision-making."* These three definitions are in contrast to technical audiences that prefer to view BI as a set of tools, technologies and algorithms that enable the creation of knowledge through the analysis of data (Ghazanfari, Jafari and Rouhani, 2011). Traditional BI focussed primarily on a data integration, through the use of a data warehouse, standard report generation and ad-hoc

queries (Nelson, 2010). Traditional BI focusses on using a consistent set of metrics to measure past performance and guide business planning (Davenport, 2010).

In today's digital age, organisations are able to collect and store endless amounts of data (Nyalungu, 2011). BI systems provide an organisation with the capacity to maximise the use of data and information by providing the structure to store and process a large volume of data (Davenport, 2006). BI also allows for the distribution of this information throughout the organisation. Therefore BI is an example of one such IS that can be used to support the management of sustainability data and information. While some studies have proposed the use of BI to manage sustainability information, very few studies have practically investigated these two themes in conjunction (Petrini and Pozzebon, 2009).

The different organisational levels have different information requirements (Figure 3-15) depending on the role of the user. The different information requirements led to the development of the three different variants of BI: Strategic BI, Tactical BI and Operational BI (Imhoff, 2006; Nelson, 2010). These variants of BI differ in terms of the currency and scope of the data and information used and produced. Operational BI uses current daily operational data and focusses on optimising short-term decision-making (Botan et al., 2010; Sabherwal and Becerra-Fernandez, 2011).

Retrospective analysis is of limited use at the strategic level of an organisation (Schmidt, 2014). At the strategic level of an organisation, the focus of decision-making is on both long-term success and long-term sustainability of the organisation, while remaining competitive in the short-term (Kownatzki, Walter, Floyd and Lechner, 2013; Mitchell, Shepherd and Sharfman, 2011). At this strategic level, managers are responsible for ensuring that the organisation is meeting its long-term goals and is operating in-line with its vision and mission. With regards to sustainability, strategic managers require a tool to assist in monitoring sustainability initiatives to determine if long-term sustainability goals are being met (Goni et al., 2013). These tools should enable managers to monitor organisational sustainability KPIs and determine if the organisation is on course to achieve its long-term goals through the use of analytical tools such as forecasting (Hulsebosch et al., 2009; Sabherwal and Becerra-Fernandez, 2011).

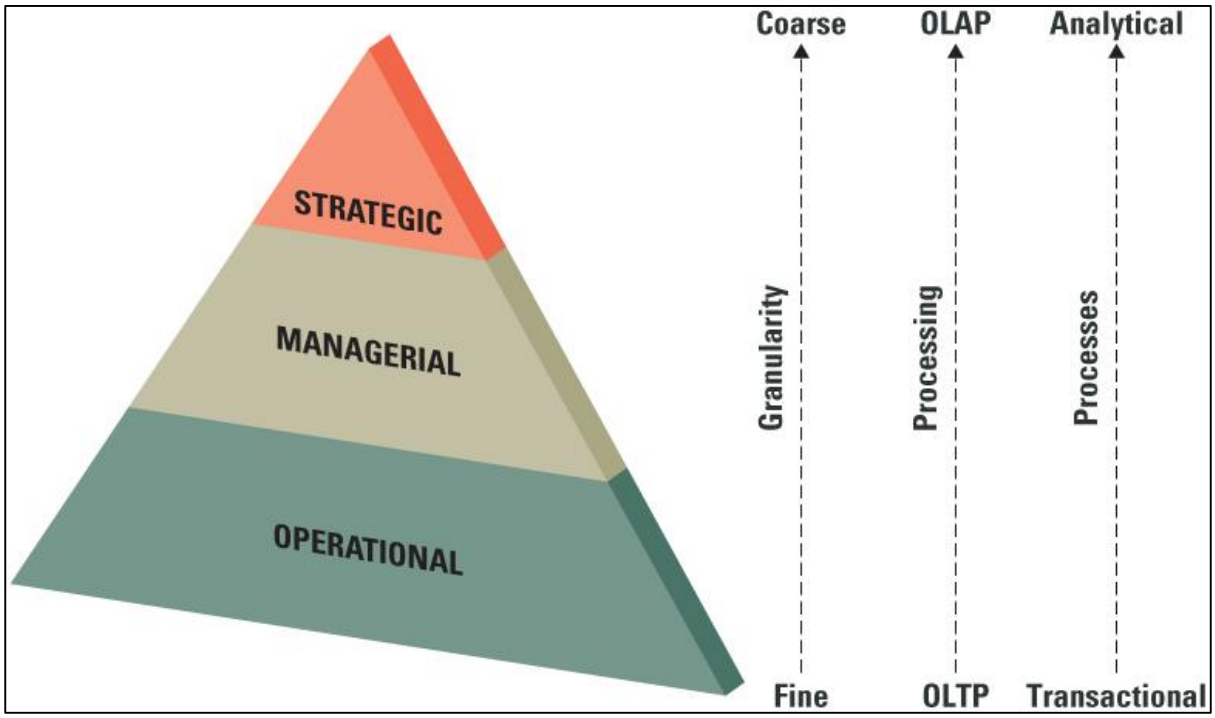

Figure 3-15: Information requirements at different organisational levels (Baltzan and Phillips, 2014)

The product of strategic BI is often referred to as strategic intelligence. Strategic intelligence is future oriented and allows an organisation to make educated decisions regarding the long-term future of the organisation (Liebowitz, 2006). Strategic intelligence enables strategic management to visualise the future direction of the organisation and allows for future planning and organisational growth, in accordance with the organisations stated mission and goals (Donner, 2014). Strategic BI therefore makes use of the BA component of BI. Operational BI is concerned with managing and optimising the daily operations of the organisation (Imhoff, 2006). The focus of operational intelligence, the product of operational BI, is the management of short-term organisational goals. Operational intelligence will most likely be used by lower-level managers. Tactical BI falls somewhere in the middle of operational and strategic BI. Tactical BI uses a combination of the traditional BI components and the newer BA components to conduct a short-term analysis to measure historical metrics.

Table 3-8: Different variants of BI (Imhoff, 2006)

	Strategic BI	**Managerial/Tactical BI**	**Operational BI**
Business Focus	Achieve long-term organizational goals	Conduct short-term analysis to achieve strategic goals	Executives, analysts, line-of-business (LOB) managers
Primary Users	Executives, analysts	Executives, analysts, line-of-business (LOB) managers	Executives, analysts, line-of-business (LOB) managers
Timeframe	Long-term (months to years)	Medium-term (days to weeks to months)	Short-term (daily)
Data	Historical metrics	Historical metrics	Right-time metrics

Many HEIs still rely on simple administrative information systems such as student systems, finance systems and human resource systems to record important institutional data (Beckett and McComb, 2012). These ISs are usually transactional in nature and therefore process transactions rather than provide information to decision makers (Beckett and McComb, 2012; Guster and Brown, 2012). To generate reports from this data is a complex and time-consuming process as data is unintegrated and often siloed. Implementing a BI system to overcome these problems can be a complex task. Implementing a BI solution in a normal business is a notoriously difficult task, however the problem is complicated further when applied to HEIs, especially if the institution is public in nature (Grabova, Darmont, Chauchat and Zolotaryova, 2010; Guster & Brown, 2012).

BI solutions are beginning to gain momentum in HEIs, with more than a third of the United Kingdom's HEIs using IBM's BI solution, IBM Cognos (Guster and Brown, 2012). Thirteen of South Africa's 23 public universities make use of the Higher Education Data Analyser (HEDA), while the remaining universities are using other BI solutions (Nyalungu, 2011). The Microsoft BI suite is used at both the University of Stellenbosch and at NMMU. The University of Pretoria and the Vaal University of Technology make use of SAP Business Objects as their BI tool. The University of the Witwatersrand makes use of two BI tools; Infobuilder and IBM Cognos.

A study by Bosire (2014) found that there is still a low level maturity for BI in South African HEIs. Most South African HEIs do not have any theoretical foundations behind the implementation of their BI tools. The implementation of the BI tools at these institutions was performed purely on the marketing of the BI vendors (Nyalungu, 2011). The low maturity of

BI in South African HEIs identified by Bosire (2014), could be a result of the lack of theoretical foundations behind the implementation. At the lowest level, simple spreadsheets are used and there is a total lack of awareness of the use of BI within the organisation. At the highest level, BI is used throughout the organisation and is extended to customers and suppliers and includes analytic capabilities to analyse the data to provide greater insight.

The limited use of BI can be attributed to several factors. Data is a key component of BI, with poor data leading to poor information created by the BI software. Data in HEIs is often unavailable and incomplete if it exists at all (Bosire, 2014). Guster and Brown (2012) argue that there are limited data integration capabilities in most HEIs, which further restricts the successful implementation of BI solutions. There is also a lack of a clear data and information management strategy in South African HEIs. The size and departmental nature of HEIs also leads to the development of a number of separate and disparate information systems. The integration of these systems is an important factor in a successful BI solution.

The implementation of a BI solution in HEIs cannot follow a one size fits all approach (Guster and Brown, 2012). There is commonality in many of the standard components of a BI solution, such as a data warehouse, reporting and analytical service and dashboards and scorecards. The actual implementation, however, will differ depending on several factors such as the data stored, the intended users of the system and the requirements of the system (Watson, 2012; Guster & Brown, 2012).

3.12 Conclusions

Drivers of sustainability in HEIs can be both internal and external. External drivers are regulatory compliance, increased pressure from external stakeholders, increased funding opportunities, competitor benchmarking, enhanced organisational reputation and the negative publicity associated with a lack of sustainability efforts. Internal drivers of sustainability are sustainability champions and/or sustainability units, risk identification, resource and cost savings, staff retention and pressure from internal stakeholders.

An IS that can help with the integration of sustainability data, producing sustainability reports and analysing the data to enable better monitoring and management of sustainability is BI. The use of BI in South African HEIs is very limited however, or poorly implemented. Many BI

implementations are not based on theoretical models and this could also be a key factor in the low maturity of BI solutions in South African HEIs. The problem with effectively managing sustainability is two-fold. There are many factors obstructing effective sustainability information management such as siloed data and poor information sharing.

Governance and strategic planning are central to effective sustainability management and are therefore placed at the centre of the proposed BI framework. A number of sustainability reporting standards exist. The two most relevant reporting standards to HEIs are STARS and the GRI. Each different category of sustainability, in both the GRI and STARS, is highlighted. The standard GRI is not optimised for higher education and therefore Lozano (2006) proposed a modified set of BI guidelines that includes a category for education. Within each of these categories is a number of indicators. The metrics related specifically to NMMU are highlighted in Section 3.10. A number of factors were identified that are obstructing effective sustainability management. Many of these issues centred on poor data and information management, including siloed data and siloed decision-making.

An initial BI framework to support strategic sustainability information management framework is proposed (Figure 3-16). The framework consists of:

- Sustainability components and data (Figure 3-8); and
- Business intelligence tools (Section 3.11).

The data component consists of an educational data store, an economic data store, a social data store and an environmental data store. These are not necessarily reflective of the exact data storage processes within an HEI as data storage differs from institution to institution. These data stores are used merely to represent that data is distributed across multiple data sources.

This chapter answered three research questions, namely:

- RQ_1: What are the drivers of sustainability in HEIs?
- RQ_2: What are the constraints to effective sustainability management in HEIs? and
- RQ_3: What are the strategic sustainability indicators at NMMU?

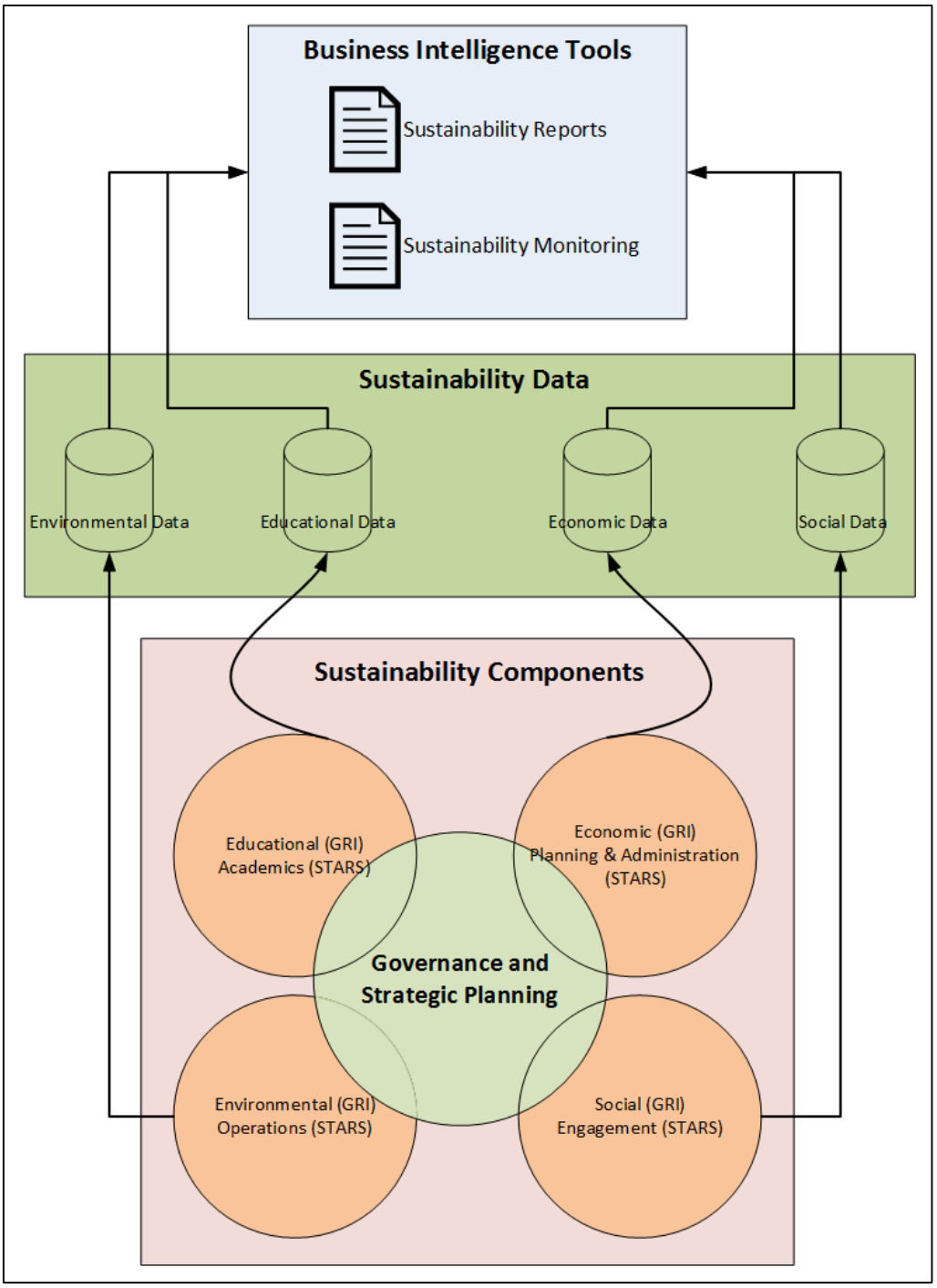

Figure 3-16: BI framework for strategic sustainability information management in Higher Education (Version 1) (Author's own construct)

The resultant deliverables were the drivers of sustainability in HEIs (Section 3.3), the constraints to effective sustainability management in HEIs (Section 3.8), and the strategic sustainability indicators at NMMU (Section 3.10). The following chapter focusses on BI, the proposed solution to overcome the constraints to effective strategic sustainability information management in HEIs.

Chapter 4. Business Intelligence to Support Effective Strategic Sustainability Information Management

4.1 Introduction

In Chapter 3 it was proposed that BI tools can be used to help manage sustainability information. The use of BI tools in South African HEIs is limited, however, and the maturity of these tools is very low. This chapter provides an overview of BI, and proposes a theoretical BI framework to support strategic sustainability management in HEIs. A BI solution is proposed to manage strategic sustainability, and the requirements of such a solution are identified. This chapter will address the second stage in the DSR process which is to identify the objectives of the artefact, the BI solution (Figure 4-1).

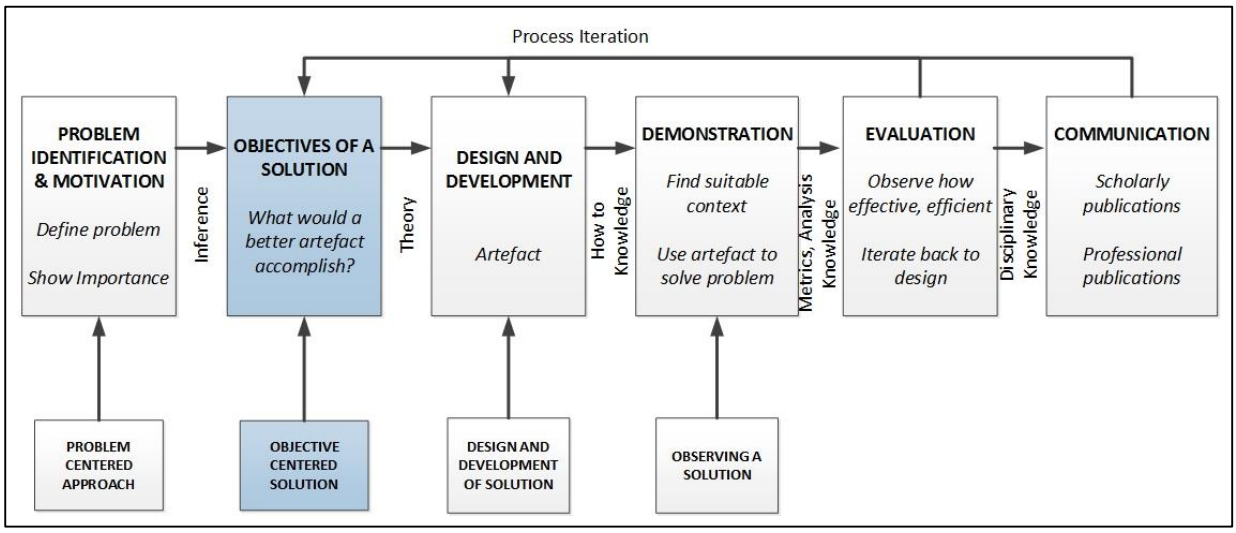

Figure 4-1: Objectives of a solution stage of DSR (Peffers et al., 2006)

This chapter seeks to answer three separate research questions, namely:

- RQ_4: What are the benefits and challenges of BI?
- RQ_5: What are the critical success factors (CSFs) of a BI project? and
- RQ_6: What are the requirements of a BI solution to support effective strategic sustainability information management in HEIs?

By answering these research questions in this chapter, a number of deliverables will be produced. These deliverables are the benefits and challenges of BI, the critical success factors

of BI, a Sustainability Management Model, the requirements of a BI solution and a BI framework for supporting strategic sustainability information management.

The chapter begins by defining the concept of BI (Section 4.2) and how BI has evolved from traditional analytics to its current form (Section 4.3). There are several components that make up a BI solution (Section 4.4). Understanding what benefits can be realised by a correctly implemented BI solution as well as understanding the challenges involved in implementing a BI solution can go a long way to determining if a BI solution can help solve the underlying organisational problem (Section 4.5). By identifying Critical Success Factors for BI, an organisation can more easily determine if a BI solution is successful (Section 4.6). Using the benefits, challenges and CSFs for BI, the Sustainability Management Model, proposed in Chapter 3, can be updated (Section 4.7). Some of the tools that can be used to implement a BI solution are analysed (Section 4.8).

BI frameworks have been developed previously, however there are no BI frameworks for strategic sustainability management in South African HEIs. An existing BI framework is analysed so that a foundation can be laid for the sustainability management framework that will be developed (Section 4.9). By analysing literature and conducting interviews with the relevant stakeholders, the objectives and requirements for a BI solution to manage strategic sustainability information are identified (Section 4.10). Thereafter a BI framework for strategic sustainability information management is proposed (Section 4.11). A full outline of the chapter is provided in Figure 4-2.

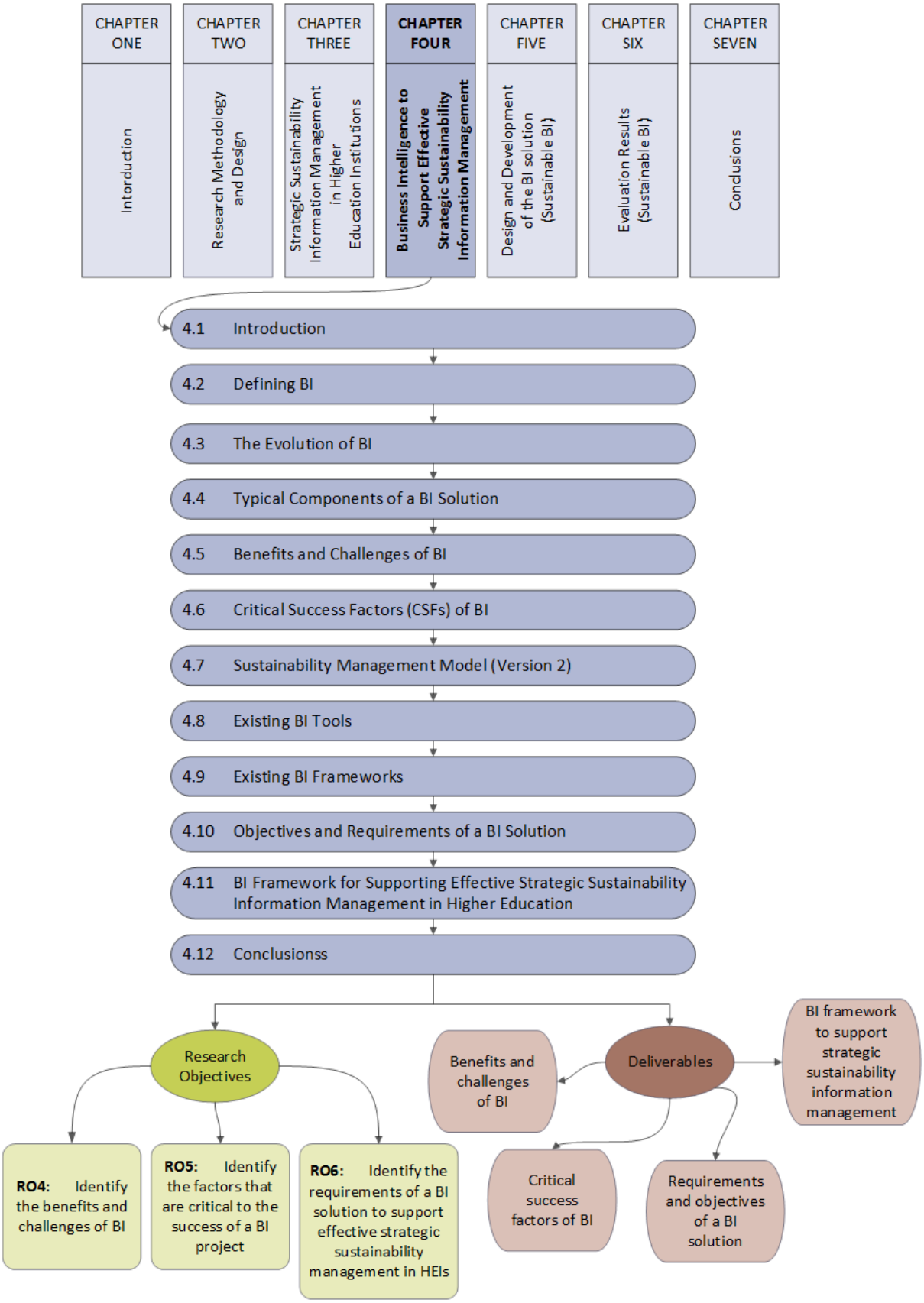

Figure 4-2: Chapter 4 layout

4.2 Defining BI

The limited nature of traditional BI and the demand for a more analytical approach led to the development of Business Analytics (BA) (Côrte-Real, Ruivo and Oliveira, 2014). The combination of these tools is often referred to as Business Intelligence and Analytics (BI&A). Businesses required a tool that focussed less on past performance and focussed more on predicting future outcomes. BA involves the process of designing and implementing sophisticated algorithms to filter and analyse large sets of organisational data (Sridhar and Dharmaji, 2013). While traditional BI still focussed on data integration and visualisation of historic and current performance, BA analyses data to discover trends and patterns that can help in predicting future outcomes (Han, Kamber and Pei, 2012; Sridhar and Dharmaji, 2013). BA is built on top of the components of traditional BI. Several authors refer to modern BI that includes the analytical components as Business Intelligence and Analytics (BI&A) (Côrte-Real et al., 2014). Chen, Chiang and Storey (2012, p. 1166) define BI&A as *"the techniques, technologies, systems, practices, methodologies and applications that analyse critical business data to help an enterprise better understand its market and make timely business decisions."* The terms BI, BA and BI&A are often used interchangeably in literature (Côrte-Real et al., 2014). For the purpose of this study, the term BI will be used and will refer to the definition provided by Chen et al. (2012) for BI&A.

The growth of BI has been fuelled by increasingly complicated decision-making processes, due to exploding data volumes, a need for greater agility of decision-making and technological progress leading to more sophisticated software solutions being made available (Sabherwal and Becerra-Fernandez, 2011). The value of BI software is dependent on the underlying data. Decision-making is better supported by up to date, real-time data, rather than by historical data (Watson, 2009). A BI solution that makes use of real time data can assist in reducing the delays in decision-making, thereby increasing the value of the action (Hackathorn, 2004).

The Institute for Operations Research and Management Science (INFORMS) defines business analytics as the "*realisation of business objectives through reporting of data to analyse trends, creating predictive models for forecasting, and optimising business processes for enhanced performance*" (INFORMS, 2010). The BI field has evolved as the requirements of organisations have shifted from a measuring and a reporting tool to a more complex analytical tool. BI consists of three main categories of analytics: (1) descriptive - the use of data to find

out what happened in the past; (2) predictive - the use of data to find out what could happen in the future; and (3) prescriptive - the use of data to prescribe the best course of action for the future (INFORMS, 2010).

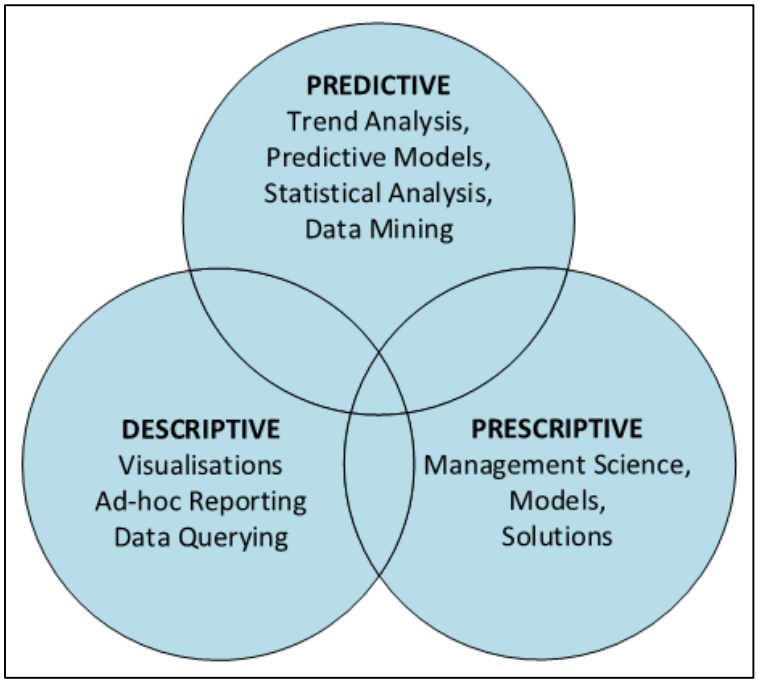

Figure 4-3: Types of analytics (Côrte-Real et al., 2014)

Descriptive analytics is the simplest form of analytics is which large amounts of data can be condensed into useful information for decision makers (Bertolucci, 2013). Descriptive analytics uses current and historic data to help business users understand current business performance and enable better decision-making (Evans and Lindner, 2012). Descriptive analytics maps very closely with traditional BI.

Predictive analytics analyses current and historic data in an effort to predict future outcomes (Evans and Lindner, 2012). Predictive analytics aims to detect patterns and relationships in this data and extrapolates these relationships forward in time. Predictive analytics makes use of trend analysis, predictive models, statistical analysis and data mining to help predict future outcomes based on current trends. Predictive modelling is the process in which a collection of mathematical techniques are used to develop a model which can be used to predict the most likely outcome given a set of inputs (Dickey, 2012; Han et al., 2012). The accuracy of the model is dependent on its reliability and amount of data available. If more data is available, the model will be more accurate.

Also referred to as optimisation analytics, prescriptive analytics assess a number of possible outcomes to determine the best possible outcome (Philpott, 2010). Prescriptive analytics makes use of descriptive and predictive models along with Monte Carlo Simulation or Bayesian models to help determine the best course of action for an organisation.

4.3 The Evolution of BI

The field of BI has evolved over the years from BI 1.0 to the latest trend of BI 3.0 (Figure 4-4). BI technologies and applications currently used in most industries can be considered as BI 1.0. BI 1.0 focuses on the analysis of structured data stored in Relational Database Model Systems (RDMS) that are collected through various legacy and ERP Systems (Chen et al., 2012). Data warehousing and the management of the data are considered the foundations of BI 1.0 as most data is internal and structured. As data warehousing is a key component, the design of data marts and the ETL processes are essential for ensuring accuracy and reliability of data.

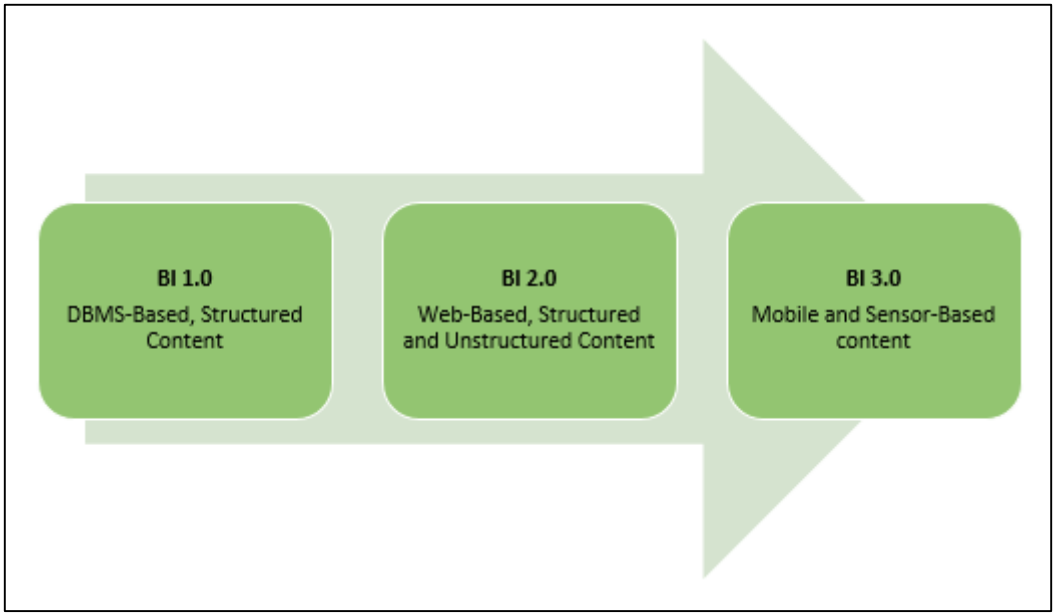

Figure 4-4: The evolution of BI (Chen et al., 2012)

BI 1.0 makes use of graphical tools to help analyse and visualise a variety of performance metrics and Key Performance Indicators (KPIs). In addition to data visualisation, data mining and predictive modelling are used to assist in predicting future outcomes (Chen et al., 2012; Eckerson, 2013).

Of the 13 capabilities of BI, the following six capabilities are considered essential for BI 1.0 (Sallam, Richardson, Hagerty and Hostmann, 2011):

1. Ad-hoc querying and reporting;
2. Performance dashboards;
3. OLAP;
4. Scorecards;
5. Predictive modelling; and
6. Data mining.

The internet and the web have provided organisations with a unique data-collection tool that previously did not exist (Chen et al., 2012). The web also allowed organisations to move their business online. Online business enabled organisations to collect unique data about their potential customers through interaction logs and cookies. This has allowed organisations to gain a better understanding of customers' needs and wants, which has enabled them to identify new business opportunities (Chen et al., 2012). This new-found information source for organisations has led to the development of web intelligence and web analytics, the core components of BI 2.0 (Doan, Ramakrishnan and Halevy, 2011). Organisational websites are a major part of most organisations in the 21st century. These websites are a key tool that enables organisations to communicate with both internal and external stakeholders. The rapid growth in the use of smartphone technology has brought about the third wave of BI technologies and has brought about an additional source of data for organisations (Chen et al., 2012; The Economist, 2011). A key characteristic of BI 3.0 is the generation of mobile and sensor-based content.

The effect that mobile technology has had on BI is not only limited to the generation of new and more data (Verkooij and Spruit, 2013). Smartphones and tablets have also provided an alternative platform to deliver the information generated by the BI software, to the relevant stakeholders (Stodder, 2012). This new phenomenon, known as Mobile BI or Mobile BI, is becoming an essential part of many organisations and enables managers to monitor and make more informed business decisions on the move. Verkooij and Spruit (2013, p. 23) define mobile BI as *"The capability that enables the mobile workforce to gain business insights through information analysis using applications optimized for mobile devices."*

4.4 Typical Components of a BI Solution

BI requires an existing data warehouse and query infrastructure in place (Harel and Sitko, 2003). It is therefore necessary to examine the components of a typical BI system to understand where the different components of BI fit in. A typical BI infrastructure consists of data sources (Section 4.4.1), an integrated data warehouse (Section 4.4.2), and reporting, analytical and monitoring tools (Section 4.4.3).

4.4.1 Data Sources

The data sources component consists of all the internal and external sources of data for the organisation (Muntean et al., 2013). Internal data typically originates from the operational databases of source systems including a variety of legacy systems and Enterprise Resource Planning (ERP) systems (Chen et al., 2012). Data sources can also be external sources, such as the internet, and existing data warehouses (Coronel, Morris and Rob, 2010). The data contained within these data sources can consist of both structured and unstructured data. The core focus of operational data sources is to record daily business transactions and perform simple query processing (Han et al., 2012). Business analysis using operational databases is difficult for several reasons including (Baltzan and Phillips, 2014):

- **Inconsistent data definitions:** Different data sources have different methods for recording data. Data can be stored in multiple formats across different data sources.
- **Lack of data standards:** Data from different data sources can differ in granularities, formats and levels.
- **Poor data quality:** Much of the data recoded in source systems is incorrect or incomplete. This data should not be relied upon to make decisions.
- **Inadequate data usefulness:** The data collected could not be used for the intended purposes.
- **Ineffective direct data access:** Typical business users do not have access to data stored in operational databases. IT professionals are required to create queries to assist users answer their questions.

Many organisations make use of data warehouses to overcome the difficulties associated with the analysis of data stored in operational data sources. A data warehouse is not a replacement for these data sources however.

4.4.2 Data Warehouses (Data Layer)

A data warehouse is a single central storage repository that stores and collects data from multiple internal and external data sources (Han et al., 2012; Ong, Siew and Wong, 2011). The primary purpose of a data warehouse is to integrate information, specifically strategic information, into a single data repository to enable business analysis (Baltzan and Phillips, 2014). A data warehouse is a collection of integrated, subject-oriented non-volatile and time-variant data that can help support decision-making (Inmon, 2005). Alternatively, Kimball, Ross, Thornthwaite, Mundy and Becker (2008) define a data warehouse as an integrated copy of transactional data that has been specifically structured to optimise querying and reporting, and data analysis. A more comprehensive definition of a data warehouse is provided by Bashien and Markus (2000), who define a data warehouse as an environment and not just a single technology. This data warehouse environment includes data stores and multiple software products that includes tools that enable data extraction, loading, storage, access, querying and reporting.

Data is loaded into a data warehouse through the extract, transform and load (ETL) process. The ETL process is responsible for extracting data from source systems and transferring it into a single data warehouse (Baltzan and Phillips, 2014). Maintaining high quality data in the data warehouse is imperative to ensuring quality information and therefore effective decision-making. Incorporated into the ETL process should be a data governance method known as data cleansing or scrubbing, which is responsible for fixing or discarding inconsistent, incorrect or incomplete information (Baltzan and Phillips, 2014; Han et al., 2012). Several types of errors in data can be rectified by data cleansing such as: missing records, redundant records, missing keys, erroneous relationships and inaccurate or incomplete data (Baltzan and Phillips, 2014).

A data warehousing architecture typically consists of three tiers or layers (Figure 4-5). The bottom tier is the actual data warehouse that is usually a relational database system. The ETL process is usually used to feed data into the data warehouse from the operational data sources. The bottom tier also consists of independent data marts, which contain a subset of the data warehouse based on the requirements of specific users. Data marts are usually confined to a specific subject such as students or staff.

The middle tier of the architecture is the online analytical processing (OLAP) server tier. OLAP tools allow users to explore and analyse multidimensional data with varying levels of

aggregation (Sabherwal and Becerra-Fernandez, 2011). OLAP enables a user to view data from different perspectives. OLAP enables functionality such as slice-and-dice, filtering, drill-down, aggregation and pivoting (Chaudhuri, Dayal and Narasayya, 2011). The top tier of the data warehousing architecture is the front-end client layer. These are the tools typically used by the front-end users. This layer enables users to query the data and produce reports, perform data analysis and perform data mining. This includes trend analysis and predictions through the use of forecasting and predictive analytics.

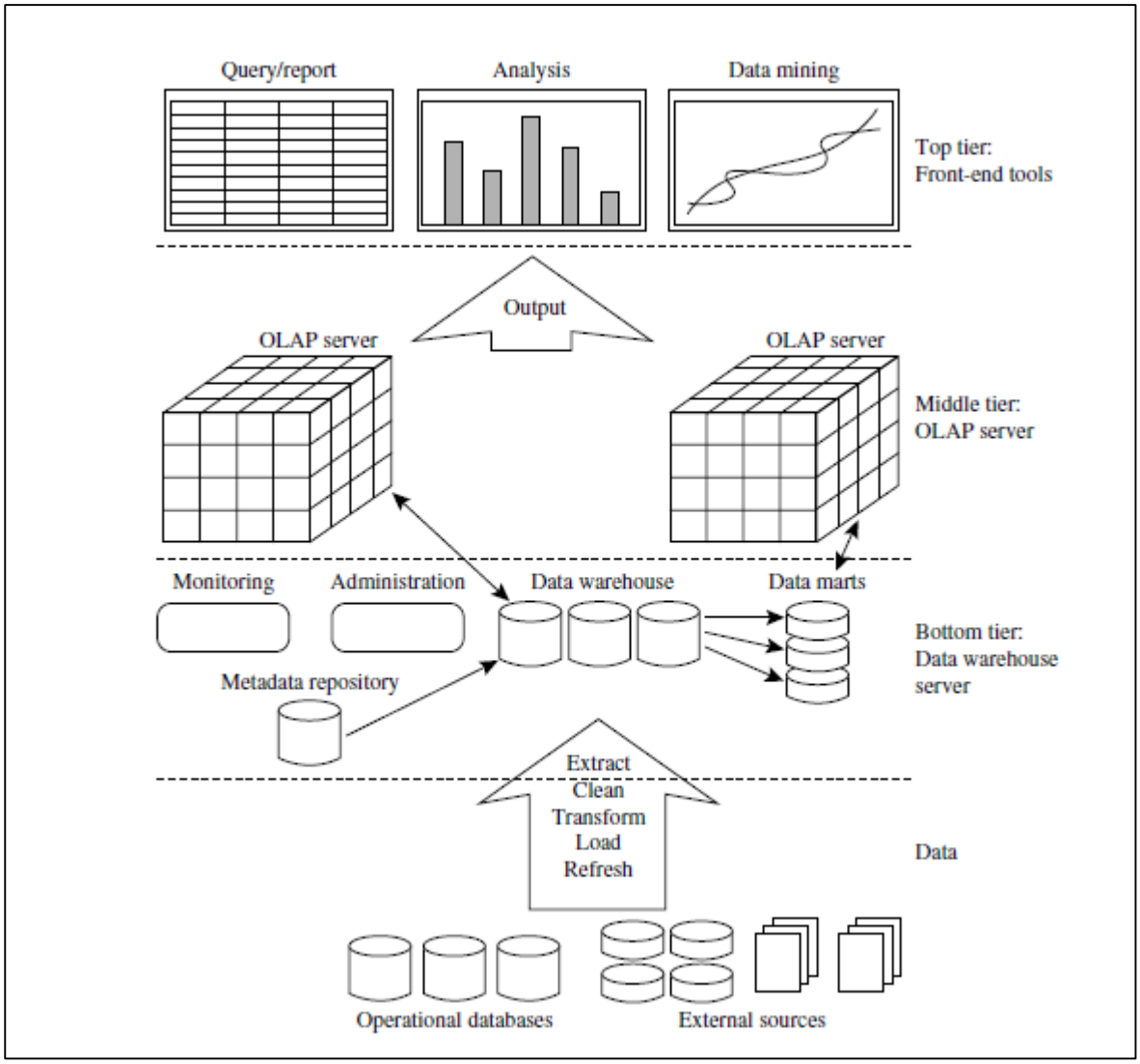

Figure 4-5: Three-tier data warehousing architecture (Han et al., 2012)

Previously users of a data warehouse included banks and other financial institutions, as well as supermarket chains, whereas HEIs were that interested in collecting and storing large amounts of data for strategic decision-making (Wierschem, Mcmillen and Mcbroom, 2003). The trend in recent times has reversed however, and many the strategic managements in HEIs are now

considering a data warehouse critical for storing data to enable better decision-making. A data warehouse in isolation however, is very limited in supporting the decision-making process. Therefore an effective BI solution built on top of the data infrastructure is required.

4.4.3 Reporting, Analytical and Monitoring Tools

Ad-hoc querying and reporting is a feature of traditional BI in which non-technical users can search for specific information and develop reports from this information. The reporting capability in any BI solution should enable the creation of formatted and interactive reports with scalable distribution capabilities (Schlegel and Sood, 2007).

Analytical tools consist of forecasting, OLAP, data mining and predictive modelling (Jooste, 2012; Muntean et al., 2013). These tools help with the analysis of data to support decision makers in the decision-making process (Chen et al., 2012; Sahay and Ranjan, 2008). Data mining, also referred to as knowledge discovery, is the process of analysing large amounts of raw data to gain meaningful insight (Han et al., 2012). A number of data mining techniques, including association detection, clustering, classification and regression analysis, can be used to help discover patterns in data which can provide the user with greater insight (Chen et al., 2012; Han et al., 2012). Dell Aquila, Tria, Lefons and Tangorra (2008) identify the capabilities typically required at the strategic level of an organisation. The tools required at the strategic level are OLAP, visualisation of information typically through the use of dashboards, and predictive modelling through the use of techniques such as forecasting.

Performance dashboards are the most popular information visualisation technique in BI (Elias, Aufaure and Bezerianos, 2013). Few (2007) provides the following definition for performance dashboards: *"A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance."* The definition provided by Few (2007) is supported by Abdelfattah (2013, p. 35) who defines a dashboard as "*a layered information delivery system that parcels out information, insights and alerts to users on demand so they can measure, monitor and manage business performance more effectively"*. As the purpose of this study is to overcome the problem of managing sustainability information in HEIs, BI, and in particular dashboards, are one such tool that can support the effective management of sustainability information.

Performance dashboards have become the mainstream visualisation tool for company executives and senior management to quickly and easily monitor Key Performance Indicators (KPIs) (Eckerson, 2011; Muntean et al., 2013). Dashboards provide management with an instant view of selected performance metrics (Gunapati, 2011). Performance dashboards also allow users to discover trends and patterns in data by aggregating data into graphical displays such as graphs. Graphical representations can communicate patterns, trends and outliers more effectively than text and tables (Eckerson, 2011). The visualisation of data through informative graphics enables users to understand complex data in less time than it takes to read a report (Gunapati, 2011).

Dashboards enable voluminous data to be converted into more meaningful information that can be used to effectively monitor and manage organisation KPIs and metrics, and make decisions based on of the information provided by the dashboards (Muntean et al., 2013; Yigitbasioglu and Velcu, 2012). According to Eckerson (2011, p. 25) a dashboard is "*a multilayer application built on a business intelligence and data integration infrastructure that enables organisations to measure, monitor and manage business performance more effectively*." A number of BI suites on the market provide dashboards that are tightly integrated with analytical tools that offer various functionalities such as heat maps, data mining, drill-up and drill-down, statistical analysis, predictive analysis, trend analysis and forecasting (Bose, 2006; Nyalungu, 2011).

The combination of dashboards with these analytical tools forms the BA subset of BI. Outcomes displayed in the dashboard include metrics and KPIs, graphical trend analysis, capacity gauges, geographical maps stoplights and other graphical visualisations (Bose, 2006; Nyalungu, 2011). Few (2006b) and Turban and Aronson (2006) identify a number of characteristics of a performance dashboard. These characteristics are:

- Data is gathered from a variety of source systems;
- Uses visual components to display information and highlight exceptions that need attention;
- Enables drill-down of data;
- Presents users with a single view of the business;
- Information is up-to-date with automatic refreshes;
- Needs to contain more than purely financial information; and

- Displays organisational KPIs in a clear and concise format.

Dashboards enable management to make decisions based on reliable, accurate and up-to-date information. Strategic managers can make use of dashboards to identify macro-level trends to help inform decisions about the growth and sustainability of the institution (Harel and Sitko, 2003). QlikView is one such BI tool that provides information visualisation through the use of dashboards (Figure 4-6).

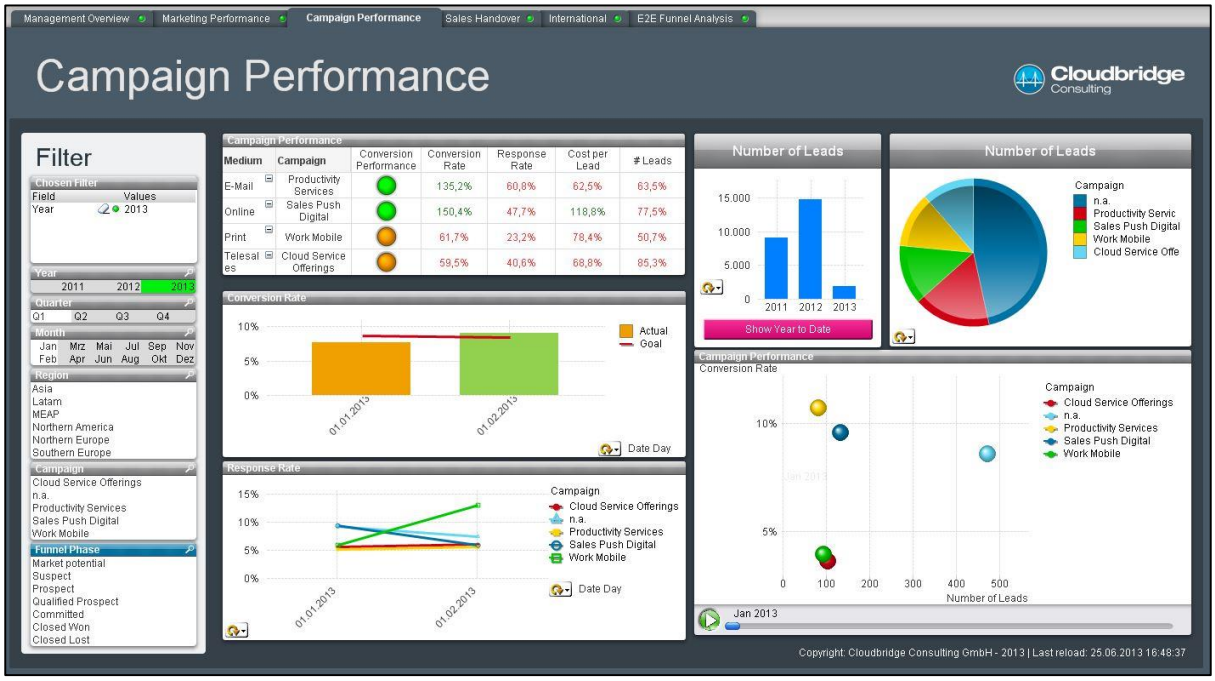

Figure 4-6: A QlikView performance dashboard (http://market.qlik.com)

Dashboards can be either static or dynamic in nature (Gunapati, 2011). Static dashboards are not interactive and merely display a number of metrics to the user. Often static dashboards are not updated instantly, and therefore do not provide users with real-time data. Dynamic dashboards provide live, up-to-date information to the users. Users can interact with dynamic dashboards and this enables users to drill-down into data, filter data and view data from different perspectives (Eckerson, 2011; Gunapati, 2011).

Scorecards are similar to performance dashboards in that they display key business information to business executives and senior management (Figure 4-7). There are, however, differences in the manner in which dashboards and scorecards present information. Whereas dashboards present a variety of information, scorecards illustrate organisational performance by focussing

on certain metrics and KPIs and comparing them to a target, benchmark, threshold or forecast (Howson, 2007).

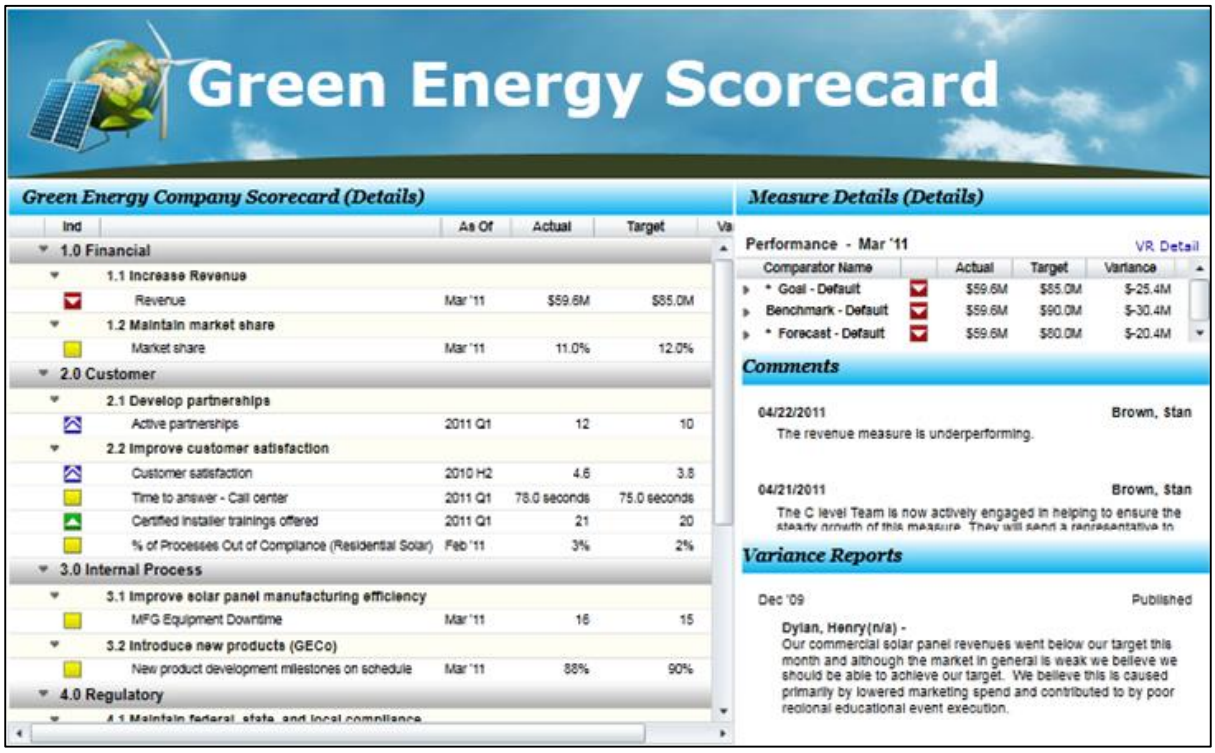

Figure 4-7: An example of a scorecard (http://blog.activestrategy.com/)

A number of steps is involved in the development of dashboards. Caraiani and Dumitrana (2005) identify five steps that should be followed in the design and development of dashboards (Figure 4-8). These steps are:

1. Set the objectives;
2. Define the list of tasks, competencies and responsibilities;
3. Set the indicators;
4. Collect information based on indicators; and
5. Develop the dashboard.

The first step of developing a dashboard involves setting the objectives of the dashboards. These objectives should outline what the organisation aims to achieve through the use of the dashboards. The second step involves defining the task competencies and responsibilities of each potential user of the dashboard. This could also be based on the operational department of the user. The purpose of defining the tasks competencies and responsibilities is to ensure that every user receives the information required to perform his/her given organisational tasks.

The third step of the process is setting the indicators to be used in the dashboards. The identified indicators should help users to determine if organisational objectives are being achieved. Indicators should be kept to a limited number however, as too many indicators can lead to information overload. Once the indicators have been identified, the source of the information used to measure those indicators must be identified and collected. Once all information has been collected and the indicators have been identified, the dashboard can be developed. Eckerson (2011) identifies an additional step, namely evaluation, in the dashboard development process.

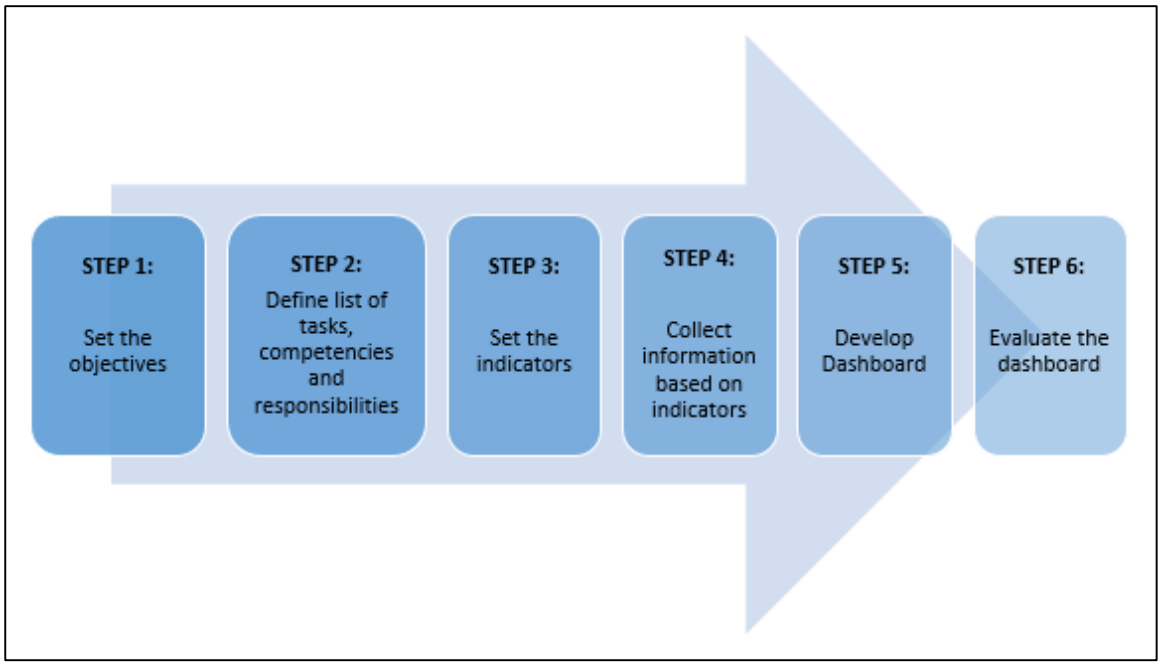

Figure 4-8: Process for developing dashboards (Author's own construct)

4.5 Benefits and Challenges of BI

A correctly implemented BI solution can help an organisation to realise a number of benefits. The benefits provided by the correct implementation of a BI solution are notoriously difficult to quantify and measure (Gibson, Arnott and Jagielska, 2004). The benefits of strategic level BI are even more difficult to quantify than those at the tactical and operational level. The benefits of BI at a strategic level are generally intangible and non-financial in nature. At an operational level the benefits are tangible and financial.

The actual benefits of a correctly implemented BI solution are far reaching and vary considerably from source to source. Benefits with a local impact are usually easier to measure than those with global impact (Gibson et al., 2004; Watson, 2009). Some benefits such as the cost savings from data mart consolidation are easy to measure and have a local impact. Other benefits such as the returns from supporting the accomplishment of strategic business objectives are more difficult to quantify and measure but have a global impact. The ease with which a benefit can be measured is influenced by the organisational level of the organisation affected. Gibson et al. (2004) argue that as the impact of the benefit becomes more strategic and global, the benefit becomes more difficult to measure (Figure 4-9).

The benefits of a BI solution will most likely be realised at the tactical and strategic levels of the organisation (Holsapple, Lee-Post and Pakath, 2014). From the findings of Watson (2009), Hočevar and Jaklič (2010) and Holsapple et al. (2014), the benefits provided by a correctly identified solution were identified (Figure 4-9). These benefits are:

- Integrated and improved information
- Time savings for data suppliers;
- Time savings for users;
- More and better information;
- Improved decision-making capabilities;
- Improvement of business processes;
- Improved support for an organisation's strategic and tactical goals; and
- Improved organisational performance.

Table 4-1: Benefits of BI at different organisational levels

Organisational Level	Benefit	Reference
Strategic	Improved organisational performance	Vesset and Mcdonough (2009); Wieder, Ossimitz and Chamoni (2014)
	Improved support for an organisation's strategic and tactical goals	Watson (2009)
Tactical	Improvement of business processes	Elbashir, Collier and Davern (2008); Watson (2009)
	Improved decision-making capabilities	Watson (2009); Watson and Wixom (2007)
	Integrated and improved information	Mihai (2014); Watson (2009)
Operational	Time savings for users	Watson (2009)
	Time savings for data suppliers	Sahay and Ranjan (2008); Watson (2009)
	Cost savings from data consolidation	Watson (2009)

The information age brought about by the connected world and technological progress which has seen continuous improvement of data storage capabilities has seen the amount of data stored by organisations increase exponentially (Sabherwal and Becerra-Fernandez, 2011). By making use of analytical capabilities, such as a what-if analysis, management can anticipate what the outcome of a decision will be, which enables management to optimise decision-making. By providing management with up-to-date and accurate information, BI can allow users to make more informed decisions. The predictive nature of some BI solutions also enables managers to identify potential problem areas before the problem occurs. BI can assist in highlighting problematic areas of the organisational performance, which enables management to respond faster and more effectively to these problem areas. The strategic goals of an organisation are usually long-term in nature whereas the tactical goals are usually medium-term.

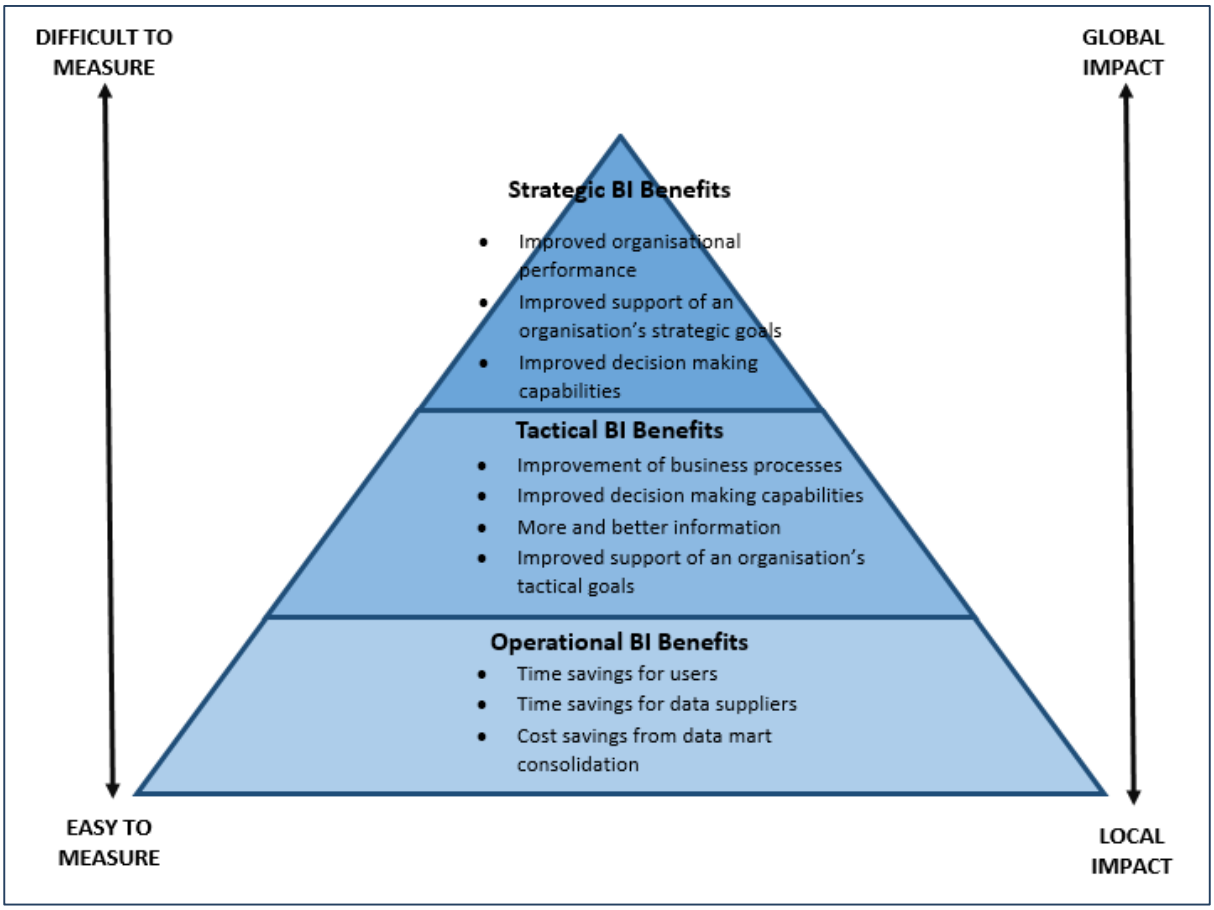

Figure 4-9: BI benefits at different organisational levels (Author's own construct)

The challenges of BI are those benefits realised at the strategic and tactical level as BI is used at these levels. Whilst there are a number of benefits of BI, there are also several challenges. Some of the more common challenges associated with BI are:

- Data quality (Otto and Reichert, 2010; Ranjan, 2008);
- Complexity (Chen et al., 2012; Sabherwal and Becerra-Fernandez, 2011);
- Cost (Microsoft, 2009; Sabherwal and Becerra-Fernandez, 2011);
- IT support (Lin, Tsai, Shiang, Kuo and Tsai, 2009); and
- Organisational alignment (Vural, 2006; Lin et al., 2009).

One of the biggest challenges of BI is data quality and in particular fragmented and incomplete data (Ranjan, 2008). Data is the foundation on which BI is built. Decisions are based on the information provided by a BI system (Otto and Reichert, 2010). Using analytical tools on inaccurate data will generate inaccurate information on which management bases its decision-making. The quality of the enterprise applications (including ERP) will affect the overall quality of the information generated by the BI applications as these applications serve as the

source systems that feed data into the data warehouse. Data can be contained in many source systems. The integration of this data into a single data warehouse can often be a complex matter as data formats can vary considerably between systems.

Another challenge associated with BI is the complexity involved in both implementing and using the system (Sabherwal and Becerra-Fernandez, 2011). Information systems collect, store and process considerable amounts of data. The complexities of these information systems increase as the business environment becomes more dynamic (Chen et al., 2012). The cost associated with implementing a BI solution is another challenge that organisations have to deal with (Sabherwal and Becerra-Fernandez, 2011). A BI solution can often be resource-intensive because multiple systems need to be integrated (Microsoft, 2009). The licencing fees for BI software can be incredibly expensive, and a complete BI solution often requires multiple pieces of software, each with its own software licence. The complex nature of integrating these technologies also leads to large costs in human resources.

A BI implementation requires substantial support from skilled IT professionals (Lin et al., 2009). IT professionals are required not only for the implementation of the BI system, but also for the long-term maintenance of the system. Skilled analysts and BI professionals are also required in the planning phase before the implementation can begin (Analytics8, 2010). It is important that organisational operations and business objectives are understood throughout all BI lifecycle stages (planning, implementation, go-live and maintenance) (Lin et al., 2009; Vural, 2006). A solid business understanding can assist with aligning the BI system with the organisational objectives and requirements. Many organisations struggle with the alignment of the BI solution and organisational goals, leading to a BI solution developed in isolation from business goals and requirements. The BI system should act as a supporting mechanism for the core business operations.

Table 4-2: Challenges of BI

BI Challenge	Authors
Data quality	Otto and Reichert (2010); Ranjan (2008)
Complexity	Chen et al. (2012); March and Hevner (2007)
High cost	Microsoft (2009); Sabherwal and Becerra-Fernandez (2011)
IT support	Analytics8 (2010); Lin et al. (2009)
Organisational alignment	Vural (2006); Lin et al. (2009)

4.6 Critical Success Factors (CSFs) of BI

Various authors have investigated the CSFs of BI (Mungree and Morien, 2013; Olszak and Ziemba, 2012). CSFs provide an organisation with insight into the factors that should be addressed to increase the chances of a new project's success (Dawson and Van Belle, 2013; Mungree and Morien, 2013; Olszak and Ziemba, 2012; Yeoh and Koronios, 2010).

There are several generic CSFs that apply to IT development projects (Dawson and Van Belle, 2013). More specific CSFs were developed for the BI domain, however (Table 4-3). BI, like any other IT project, should have the support of senior management (Chenoweth, Corral and Demirkan, 2006; Mungree and Morien, 2013; Yeoh and Koronios, 2010). This support can help to manage the change process and overcome any resistance within the organisation. A senior executive should be responsible for the management and overall guidance of the project. This includes allocating resources and acting as the go-between of the project team and the senior management team. Management should ensure that both the development team and the staff in the organisation that will make use of the system should have the appropriate knowledge, skills and experience (Mungree and Morien, 2013; Wixom and Watson, 2001; Yeoh and Koronios, 2010). The BI system must support the organisation's strategies and objectives and therefore, the requirements of the system need to be clearly established and be aligned with the organisation's strategic vision (Mungree and Morien, 2013; Yeoh and Koronios, 2010). The system should, however, be able to adapt to changing business requirements. The system also needs to be justified financially. The return that the system provides should outweigh the costs required to implement the system, however adequate resources should be provided to ensure the success of the project. It is also important to involve the users in the development process as this will ensure greater user support (Mungree and Morien, 2013; Yeoh and Koronios, 2010).

Table 4-3: CSFs for BI

Critical Success Factor	Author
1. Committed senior management support	Chenoweth et al. (2006); Mungree and Morien (2013); Yeoh and Koronios (2010)
2. Appropriate team skills	Mungree and Morien (2013); Wixom and Watson (2001); Yeoh and Koronios (2010)
3. Flexible and appropriate framework	Mungree and Morien (2013); Yeoh and Koronios (2010)
4. Align BI strategy with business objectives	Mungree and Morien (2013); Yeoh and Koronios (2010)
5. Clear vision and well-defined information system requirements	Mungree and Morien (2013); Philpott (2010); Yeoh and Koronios (2010)
6. User-oriented change management	Mungree and Morien (2013); Yeoh and Koronios (2010)
7. Effective data management	Mungree and Morien (2013); Yeoh and Koronios (2010); Wixom and Watson (2001)
8. Committed and informed executive sponsor	Mungree and Morien (2013); Yeoh and Koronios (2010)
9. Project scope management	Mungree and Morien (2013)
10. Adequate resources	Mungree and Morien (2013)

From a technical perspective, there should be a good organisational fit with the BI hardware and software. Quality data is the bedrock of a quality BI system (Mungree and Morien, 2013; Wixom and Watson, 2001; Yeoh and Koronios, 2010). Effective data governance procedures should be in place. As part of effective data governance, ETL applications should ensure the integrity and accuracy of the underlying data. Potential users of the system should be actively involved in the design and development of the system to ensure that user requirements are met. By meeting the requirements of the user, there is a greater chance of user acceptance.

4.7 Sustainability Management Model (Version 2)

By critically analysing literature on BI, the Sustainability Management Model (Figure 3-10) was extended to incorporate the role that BI can play (Figure 4-10). The scope of this research is focused on the constraints related to the use of information and IS. The benefits provided by a BI solution can help overcome the information and IS constraints to effective, sustainability management. BI is therefore the ideal technology for managing sustainability information

management. In order to ensure that the BI solution is successfully implemented, a number of CSFs were identified.

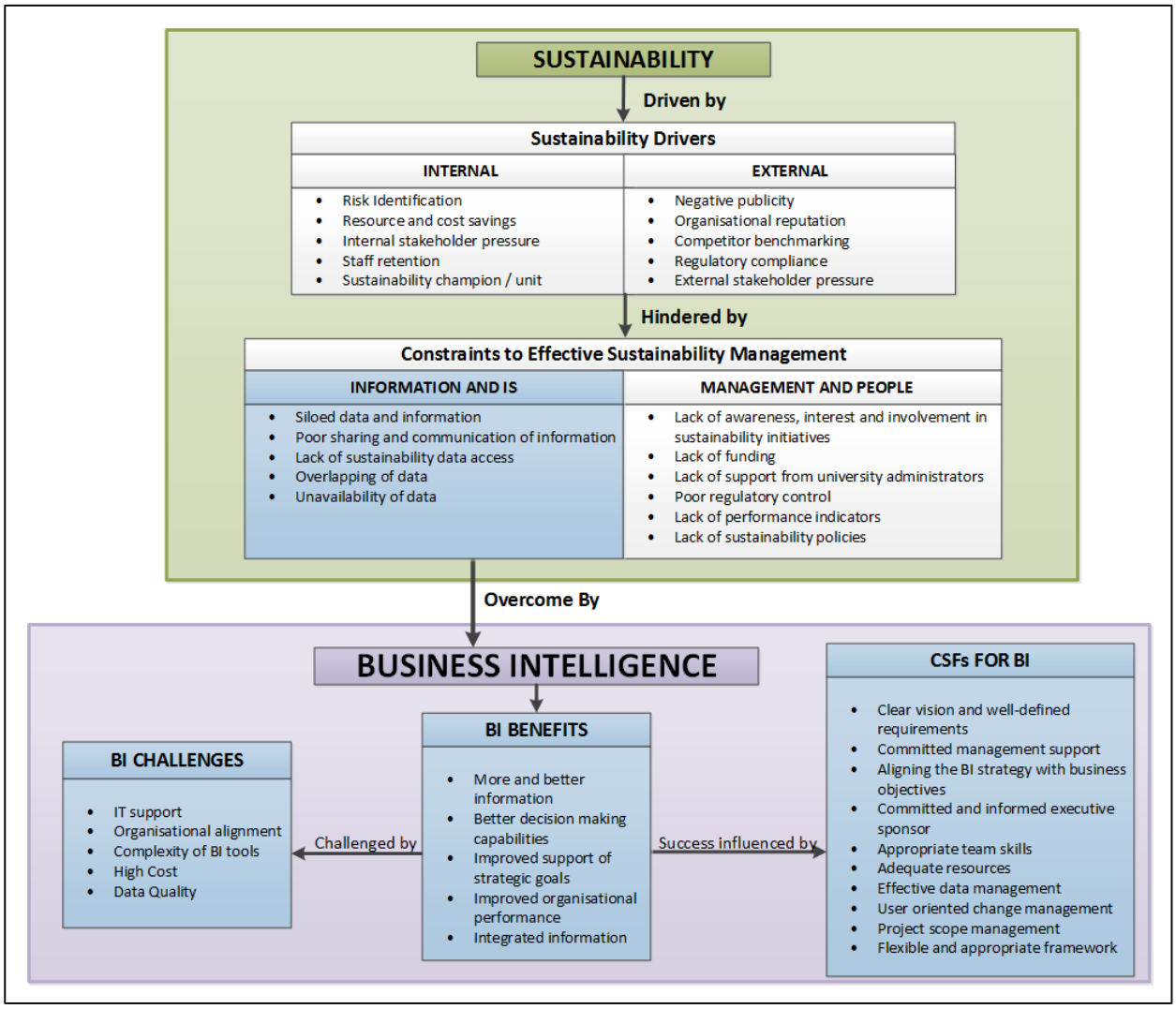

Figure 4-10: Sustainability Management Model (Version 2) (Author's own construct)

4.8 Existing BI Tools

A number of vendors provide BI tools. An analysis of these existing tools can provide a better understanding of the advantages and disadvantages of these tools. BI vendors are subdivided into three different categories: Mega-Vendors (Section 4.8.1), Major Independent Vendors (Section 4.8.2) and Other Notable Vendors (Few, 2006b; Yigitbasioglu and Velcu, 2012). Table 4-4 provides some of the more popular vendors in each category.

Table 4-4: Summary of BI vendor categories (Sabherwal and Becerra-Fernandez, 2011)

Category	Vendors
Mega-Vendors	IBM, Microsoft, Oracle, SAP
Major Independent BI Vendors	SAS, Microstrategy, Information Builders, Tibco Software inc., QlikTech, Acutate, Tableau.
Other Notable BI Vendors	Teradata, HP, Arcplan, Panorama Software

The selection of a BI vendor is dependent on the requirements of the organisation. A 2013 Forrester report found that SAS, IBM and SAP are the leaders in big data analytics and predictive analytics (Sabherwal and Becerra-Fernandez, 2011). The report also identified Tibco Software, Oracle, StatSoft and KXEN as strong performers in big data analytics and predictive analytics. Each year Gartner produces a magic quadrant for BI vendors in which it rates BI vendors (Figure 4-11).

4.8.1 Mega-Vendors

The number of BI vendors has decreased significantly due to acquisitions of independent BI vendors by large software companies (Liyakasa, 2013). Leading independent BI vendors Cognos, Business Objects and Hyperion were acquired by leading software companies IBM, SAP and Oracle respectively. There are several advantages offered by BI mega vendors. BI suites of mega vendors are often used in conjunction with other software products by the same software company, decreasing the problem of integrating the BI system with other software systems (Sabherwal and Becerra-Fernandez, 2011). The customer can also enter into one long-term contract for all software systems as opposed to many separate contracts. The BI tools of each of these mega vendors differ considerably. Each of these tools is analysed below.

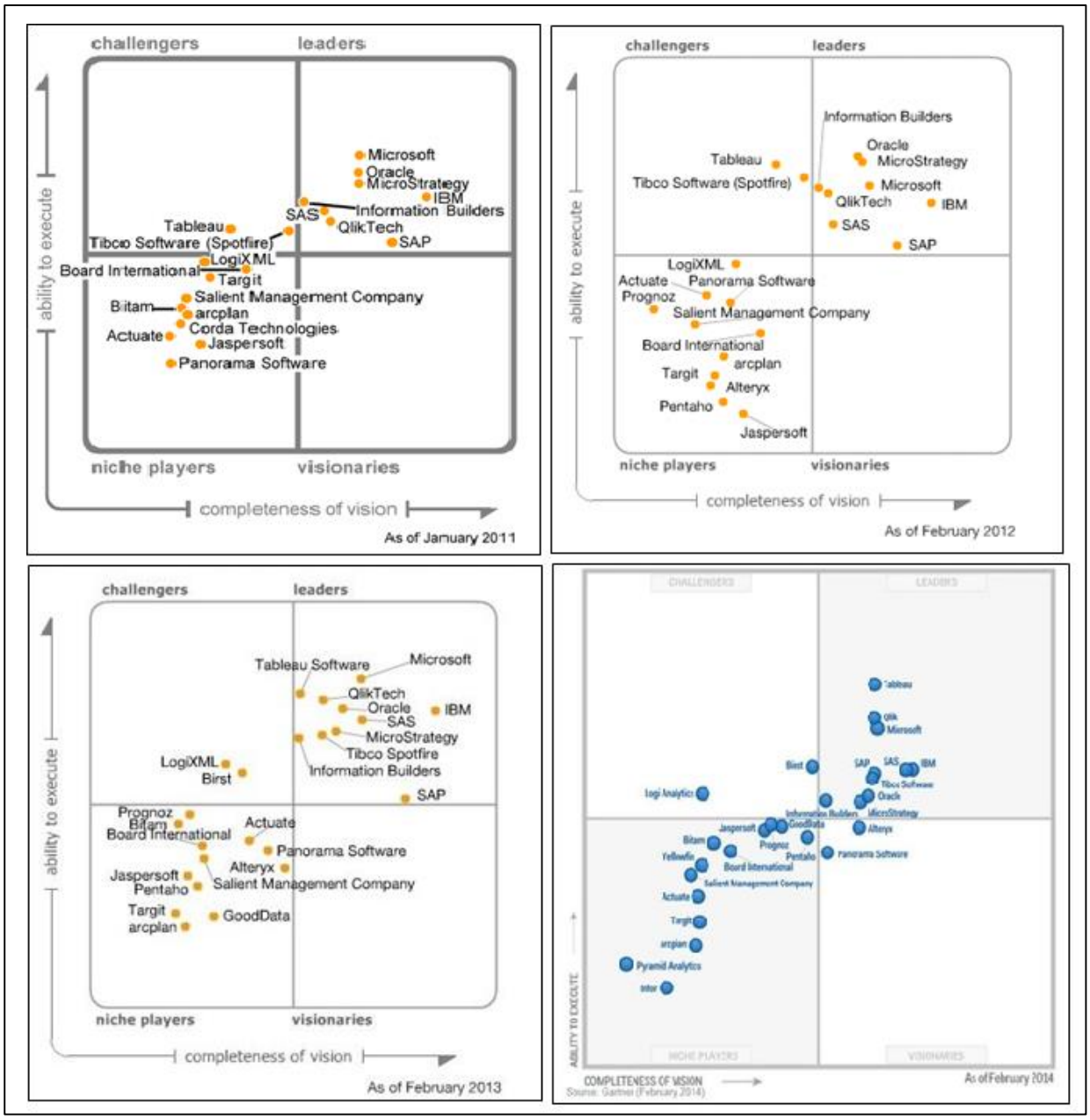

Figure 4-11: Gartner's BI magic quadrant for 2011-2014

4.8.1.1 SAP

The SAP Business Objects BI platform offers a wide range of analytic capabilities. This platform is best suited to large Information Technology (IT) deployments that have high governance and administrative capabilities (Sabherwal and Becerra-Fernandez, 2011). Most organisations that use SAP Business Objects use SAP as their primary ERP system. Many of these organisations use SAP Business Objects because of the ease of integration with their SAP ERP system.

SAP acquired both HANA and KXEN in 2013 to advance both its predictive and prescriptive analytic capabilities. The acquisition was aimed at overcoming SAP's apparent weakness in the analytics field. Although the acquisition of these tools has improved SAP's analytic capabilities, the integration of these tools with SAP's Business Objects Suite is still a work in progress and a great deal of work needs to be done to integrate these new tools into the SAP BI suite. Problems have also been reported with the upgrading of SAP Business Objects BI to a newer version. Although improvements have been made recently to ensure that migration to a newer system is easier, it is still well below the industry standard (Hostmann, Parenteau, Sallam, Tapadinhas and Yuen, 2014). SAP Business Objects BI is used mainly as a reporting tool by its customers. The number of customers that use SAP for interactive discovery and visualisation is well below that of similar products (Hostmann et al., 2014).

4.8.1.2 Microsoft

Microsoft Power BI 365 is the latest BI tool provided by Microsoft. Microsoft harnesses the power of existing Microsoft Office technologies to provide business analytics capabilities (Hostmann et al., 2014). By making use of these technologies, Microsoft can ensure that users can make use of a familiar tool that is easy to learn. According to Gartner's (2014) BI Magic Quadrant report, Microsoft is a leader in the market. Power BI is provides a collection of tools and services that enable users to visualise data and share discoveries throughout the organisation (Figure 4-12).

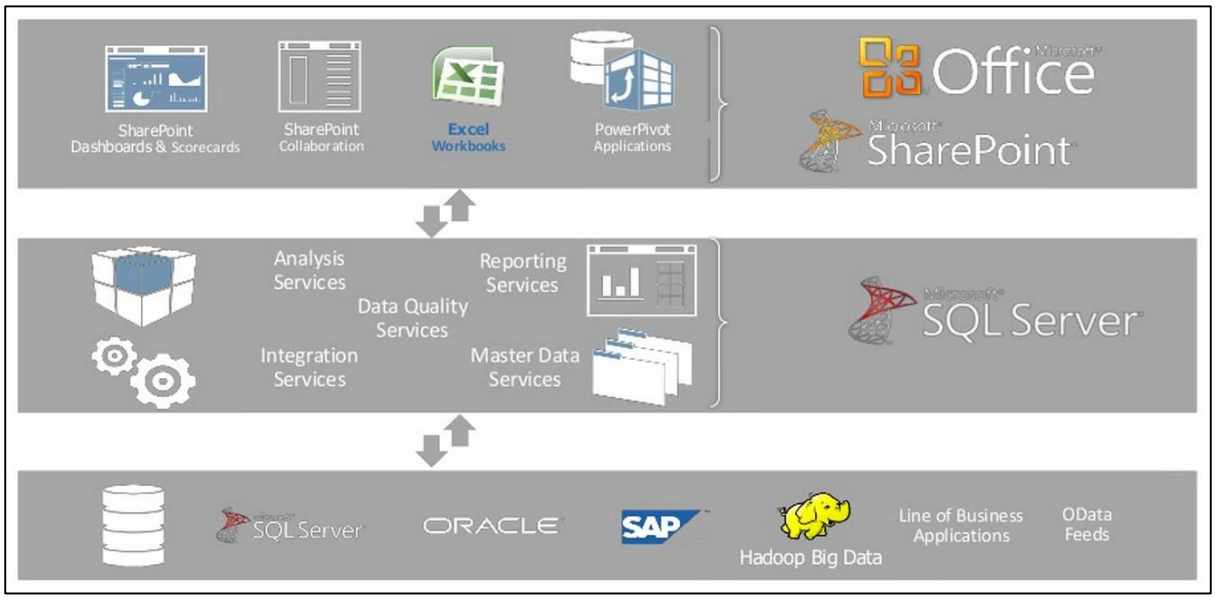

Figure 4-12: Microsoft Power BI architecture (Lu, 2014)

The bottom layer of the architecture provides the source data on which the BI solution functions. This data is provided by source systems such as SAP ERP systems. The middle layer of the Microsoft Power BI Architecture maps to the ETL processes, the data layer, the reporting layer and components of the analytical layer of the Muntean et al. (2013) framework. With Microsoft Power BI, SQL Server is used to integrate the data from the numerous disparate data sources into one single data warehouse (Frechette, 2013). The Data Quality Services provided by SQL server ensure that the data is accurate and reliable. SQL Server also provides Reporting Services to generate predetermined reports, which have a similar functionality to the reporting layer of the generic BI framework. SQL server analysis services contain the key components of the analytical layer of the generic BI framework. Analysis services enable the development of analytical models and predictive models, as well as including OLAP functionality.

The top layer of the architecture has similar functionality to the monitoring layer and the presentation layer of the generic BI framework. Microsoft Excel or Microsoft SharePoint can be used to develop dashboards that can help an organisation to monitor KPIs and other metrics. These dashboards, as well as some of the components in the other two layers, are delivered to the user using Microsoft SharePoint Services. SharePoint can therefore act as a key component of the monitoring layer, as well as for the presentation layer.

4.8.1.3 IBM

The acquisition of Cognos enabled IBM to be considered a BI mega-vendor (Frechette, 2013). IBM offers a complete range of enterprise-grade BI tools, performance management and advanced analytics capabilities. IBM is seen as a leader in the analytics field and is constantly pushing the boundaries. One of IBM's strategic objectives is to grow and improve its BI, analytics and performance-management capabilities. These strategic objectives have seen IBM become the leading vendor for Completeness of Vision (Hostmann et al., 2014). IBM is also responsible for some of the largest BI deployments. The data repositories accessed in IBM implementations average over 10TB in size, an average of 2 428 users, and queries accessed averaging 1 858GB. IBM's traditional BI capabilities such as ad hoc reporting, dashboards and scorecards, and OLAP are also rated above the average (Hostmann et al., 2014).

4.8.2 Independent BI Vendors

Although the BI market is still dominated by the mega vendors, independent BI vendors are gaining popularity as consumers begin to look for a cheaper and more flexible option (Kernochan, 2014). Organisations usually make use of an independent BI vendor if a tactical approach to sourcing IT products is used. Using a tactical approach, customers source the best possible software solution for each problem, and do not make use of one vendor to provide all software systems (Kelly, 2010).

The biggest benefit of choosing an independent BI vendor is the ability to mix and match several solutions depending on the requirements of the organisation, thereby allowing an organisation to select the best tool for each requirement. The customers also have greater influence over future product releases, ensuring that future products are more suited to the given requirements. Licencing fees are also lower and less complicated than those of the mega vendors (Sabherwal and Becerra-Fernandez, 2011).

QlikTech was a pioneer of the data discovery segment of BI. It has therefore become a market leader in data discovery. QlikTech's Qlikview BI suite offers numerous BI capabilities that make use of an in-memory associative search engine with a growing number of information access and query connectors (Cuzzillo, 2008). The Qlikview suite is known for its intuitive interactive experience. Users can interact with dashboards and scorecards, which enables users to freely explore patterns, connections and outliers in data without creating models in advance. The main reason that Qlikview customers chose the platform is because of its ease of use for both end-users and developers. The ease of use for developers has resulted in much lower average implementation costs than other BI platforms (Hostmann et al., 2014).

4.9 Existing BI Frameworks

A number of existing BI frameworks have been developed (Chandler, Hostmann, Rayner and Herschel, 2011). These BI frameworks have been developed based on their use in a specific sector. This section presents two existing frameworks that are relevant to the BI framework to support the management of sustainability information. A generic structural BI framework is presented that highlights the different tasks and capabilities required for a BI implementation (Section 4.9.1). The second framework presented is a BI framework for HEIs, which provides the interrelated components required for a BI implementation in an HEI (Section 4.9.2).

4.9.1 Structural BI Framework

Acito and Khatri (2014) provide a generic BI framework that highlights the different components required for a successful BI Implementation. At the top level of this framework are the strategy and desirable behaviours components. Without clearly defined strategic objectives, an organisation cannot determine what should be done with raw data or a BI solution. A BI solution should be clearly aligned with the strategic goals of an organisation.

Business performance management (BPM) consists of the tasks and capabilities of a BI solution. The tasks are performed by the users of the BI system. These users can perform one or more of three tasks, namely: produce and/or consume insights and enable the creation of insights (Vukšić, Bach and Popovič, 2013). Producing insight refers to the tasks performed by users who conduct analysis on the data. Consume refers to users who make use of analytics to assist in decision-making. Enabling the creation of insights includes all the IT tools and technologies required for performing analytics to assist with decision-making. The Acito and Khatri (2014) framework has been expanded to include a brief outline of the tasks and capabilities (Figure 4-13).

Three types of capabilities are required in a BI solution: decision, analytic and information. The decision capabilities are the tools responsible for delivering information to support decision-making such as reports, dashboards and scorecards. The analytic capabilities are the tools that perform analysis on the raw data. These include inferential statistics, predictive analytics and forecasting (Acito and Khatri, 2014). Information capabilities are the technologies that help an organisation describe, organise, integrate and share data assets. The key focus of BI is leveraging value from raw data. The foundation of any BI solution is therefore the underlying data.

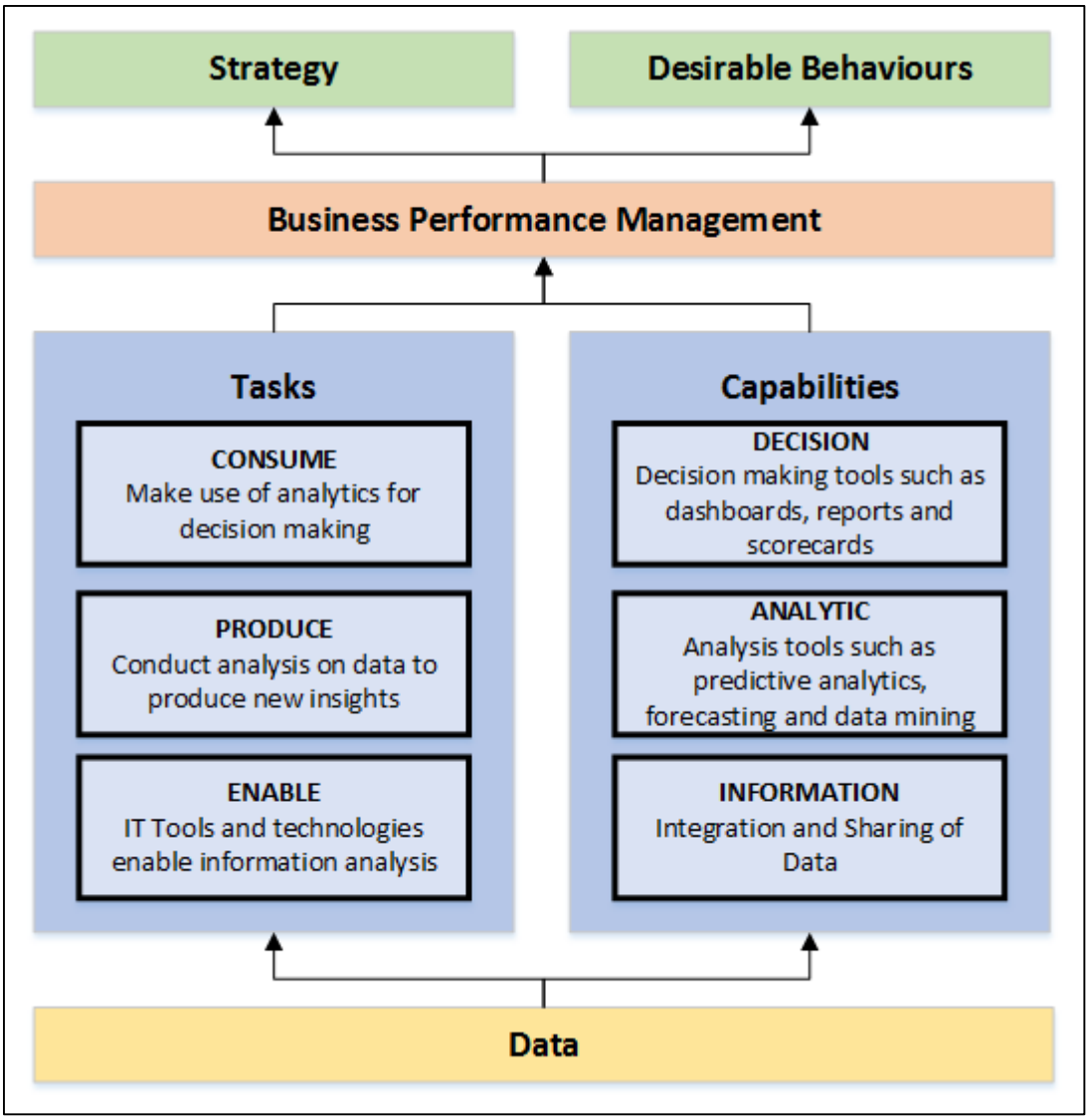

Figure 4-13: A generic structural BI framework [Adapted from Acito and Khatri (2014)]

4.9.2 BI Framework for HEIs

The increased growth of BI implementations in the higher education sector has led to the development of BI architectural frameworks developed specifically for HEIs. Muntean et al. (2013) have developed one such framework (Figure 4-14). The framework proposed by Muntean et al. (2013) consists of five layers, namely:

- The monitoring layer;
- The analytical layer;
- The reporting layer;
- The data layer; and

- Presentation layer (university portal).

The framework also consists of source systems, the ETL process, and the university portal. The source systems are all the operational databases used by the university and include the finance database, HR database, research database, student database and external data sources. The data in these source systems goes through the ETL process in order to be integrated and transferred into the university data warehouse that makes up the data layer of the framework.

The reporting layer consists of ad-hoc query and reporting capabilities. The ad-hoc querying capability allows users to query a database to filter and select the desired data (Ong et al., 2011). Users can generate reports based on these ad-hoc queries and predetermined queries and metrics. These reporting capabilities and ad-hoc querying capabilities are usually used by middle-level management in the tactical level, or lower level management in the operational level. The reporting layer, the data layer and the ETL process that extract data from the operational data sources are the components of traditional BI (Section 4.2). The analytical layer and monitoring layer built on top of the reporting and data layer are the extended components of BI, which combined with the data layer and reporting layer, make up BA.

The analytical layer consists of OLAP, data mining and forecasting capabilities. OLAP involves developing data cubes from the data warehouse in order to reduce query time (Muntean et al., 2013). These cubes enable users to easily perform the four basic OLAP operations, namely roll-up or drill-up, drill-down, slice and dice, and pivot. Data mining is used to find patterns in large sets of data through the use of complex algorithms (Ong et al., 2011). Forecasting is the process of predicting future outcomes based on historical data (Han et al., 2012). These capabilities are also the core capabilities of the BA field. These capabilities are all key components that enable predictive analytics and are key components that enable the creation of strategic intelligence.

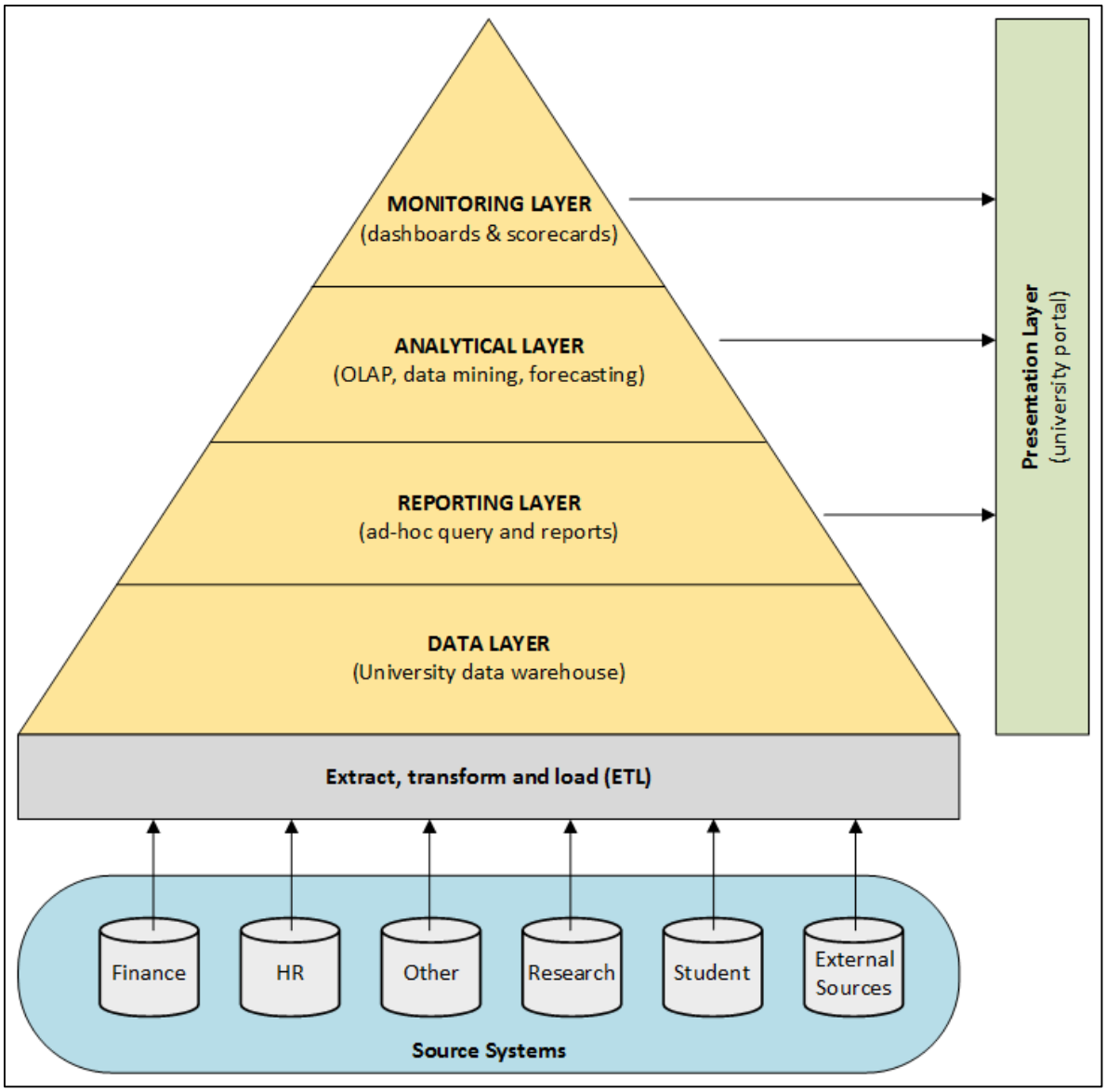

Figure 4-14: BI framework for HEIs (Muntean et al., 2013)

The information created in the analytical layer is usually presented to management in the monitoring layer (Kourentzes, Petropoulos and Trapero, 2014). The monitoring layer makes use of both performance dashboards and scorecards to present the strategic intelligence, created in the analytical layer, to the strategic management in the organisation (Ong et al., 2011). Dashboards can be used to monitor and manage sustainability at a strategic level by providing constant up-to-date information for the predetermined metrics and KPIs identified by senior management. The final component of the framework is the university portal, which can also be referred to as the presentation layer (Muntean et al., 2013). This layer is responsible for delivering the content of the other layers in the framework to the intended users.

Muntean et al. (2013) identified a number of different dashboards that can be used in HEIs (Figure 4-15). These dashboards are: research dashboards, finance dashboards, university business processes and operations dashboards, staff and workplace satisfaction dashboards, student teaching and learning dashboards and environmental dashboards.

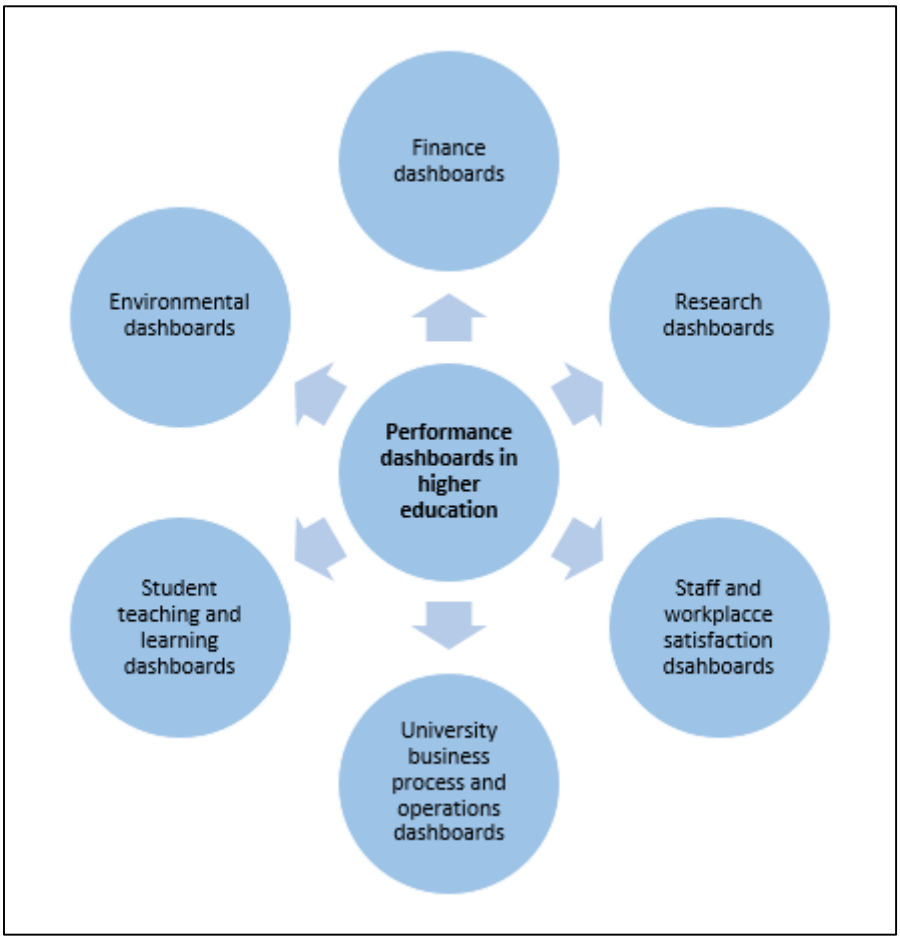

Figure 4-15: Performance dashboards in HEIs (Muntean et al. 2013)

A number of these dashboards map directly to the STARS credit list (Table 4-5). This highlights the important role that dashboards have in monitoring and managing sustainability in HEIs. The research dashboards and teaching and learning dashboards will both focus on the STARS Academic Credits. The university business process and operations dashboards and the environmental dashboards will both focus on the STARS Operations Credits. The finance dashboards will focus on the STARS Planning and Administration Credits. The staff and workplace satisfaction dashboards will focus on the STARS engagement credits.

Table 4-5: Mapping of performance dashboards to STARS credits and GRI

Performance Dashboard (Muntean et al., 2013)	**STARS Credits (AASHE, 2011)**	**GRI for HEIs (Lozano, 2011)**
Research Dashboards	Academics (AC1 – AC11)	Educational (Research)
Student Teaching and Learning Dashboards		Educational (Curriculum) Educational (Service)
Finance Dashboards	Planning & Admin (PA4 - PA8, PA13 – PA15)	Economic (Direct Economic Impacts)
University Business Processes and Operations Dashboards	Operations (OP1-OP28)	Educational (Curriculum) Educational (Service) Educational (Research)
Staff & Workplace Satisfaction Dashboards	Engagement (EN1 - EN16)	Social (Labour Practices and decent work) Social (Human Rights)
Environmental Dashboards	Operations (OP1 - OP5, OP8- OP11, OP18 - OP28)	Environmental (Environmental Impact)

4.10 Objectives and Requirements of a BI Solution

It is important to define the requirements of the BI solution to be developed as it serves as an input to the design and development activity of the DSR methodology. There are several different techniques that can be used in the requirements gathering process, such as interviews, surveys and extant-systems analysis (Satzinger, Jackson and Burd, 2011). The requirements of the BI solution were identified through an analysis of existing literature and interviews with the relevant stakeholders (Van Leeve, 2015; Levendal, 2015) (Section 4.10.1). Once the requirements of the BI solution were identified, the existing BI solution at NMMU, InfoPoint, was analysed to determine which of these requirements were met (Section 4.10.2).

4.10.1 Objectives and Requirements

Several high-level objectives were identified for the BI solution to support strategic sustainability management. These objectives are:

- The BI solution should provide up-to-date strategic sustainability information to the relevant stakeholders;
- The information provided by the BI solution should be based on predetermined KPIs;

- The BI solution should also provide forward-looking information and should not be confined to historic data;
- The BI solution must support the sharing of strategic sustainability information.

The functional requirements and non-functional requirements of a BI solution to support strategic sustainability management are identified (Table 4-6). The requirements were identified through interviews and/or analysing literature. The requirements took into consideration the characteristics of performance dashboards (Section 4.4). The BI solution should provide strategic management with up to date and accurate strategic sustainability information, which will enable strategic management to better monitor and manage sustainability efforts. The information should be provided to management through dynamic and interactive dashboards. The information should be aggregated according to these KPIs, but should provide drill-down capabilities to enable root-cause analysis. The information provided by the BI solution should not be limited to current and historic information and should provide forward-looking information through the use of forecasting and/or predictive modelling. The BI solution should also enable management to share information with each other, to ensure that the silo effect can be overcome. Another mechanism to overcome the silo effect is to integrate multiple aspects of sustainability in a single BI solution.

In addition to the functional requirements, a number of non-functional requirements have been established. These non-functional requirements will ensure that the system provides users with the correct information in an efficient and effective manner. As many of the members of strategic management at NMMU do not have a background in technology, the BI solution should also be easy to use and easy to learn.

Table 4-6: Requirements of a BI solution to support strategic sustainability information management

Number	Requirement	Literature	Interviews
Functional Requirements			
R1	The BI solution must provide up-to-date sustainability information through reports, dashboards and scorecards.	✔	✔
R2	Dashboards should be dynamic and interactive.	✔	
R3	The BI solution should provide information to the users to assist in monitoring KPIs.	✔	✔
R4	The information should be aggregated but allow drill-down capabilities to enable root-cause analysis.	✔	✔
R5	The BI solution should make use of forecasting/predictive capabilities.	✔	
R6	The BI solution should enable the sharing of sustainability information.	✔	
R7	Information should be gathered from multiple sources..	✔	✔
R8	The BI solution should cover more than one aspect of sustainability.	✔	✔
Non-functional Requirements			
R9	The BI solution must be easy to use.	✔	✔
R10	The BI solution must be easy to learn.	✔	✔
R11	The BI solution must provide information to users in an effective manner.	✔	✔
R12	The BI solution must provide information to users in an efficient manner.	✔	✔

4.10.2 Extant-Systems Analysis

An analysis of the existing BI system at NMMU, InfoPoint, was conducted to determine its capabilities and if the system met the identified requirements for a BI system to support strategic sustainability information management (Table 4-6). The analysis was conducted by the researcher in an interview with the MIS analyst responsible for developing the system. The analysis of InfoPoint revealed that not all the requirements of a BI solution to support strategic sustainability information management were met (Table 4-7).

Table 4-7: InfoPoint capabilities

Requirement Number	Requirement	Requirement Satisfied by InfoPoint
R1	The BI solution must provide up-to-date sustainability information through reports, dashboards and scorecards.	✔
R2	Dashboards should be dynamic and interactive.	✘
R3	The BI solution should provide information to the users to assist in monitoring KPIs.	✔
R4	The information should be aggregated but allow drill-down capabilities to enable root-cause analysis.	✔
R5	The BI solution should make use of forecasting/predictive capabilities.	✘
R6	The BI solution should enable the sharing of sustainability information.	✔
R7	Information should be gathered from multiple sources.	✔
R8	The BI solution should cover more than one aspect of sustainability.	✘

InfoPoint made no use of forecasting or predictive capabilities, and is entirely historical. InfoPoint also does not cover multiple aspects of sustainability. InfoPoint focusses entirely on educational data and ignores environmental, financial and social data.

4.11 BI Framework for Supporting Effective Strategic Sustainability Information Management in Higher Education

Based on the initial literature study, a BI framework to support strategic sustainability information management in South African HEIs was developed (Figure 4-16). The framework consists of a number of components highlighted in the preceding sections. The components of the framework are:

- Sustainability components and data sources (Section 3.3);
- The operational data sources (Section 4.4.1);
- The extract, transform and load (ETL) process (Section 4.4.2);
- The data layer (Section 4.4.2);
- The reporting layer (Section 4.4.3);
- The analytical layer (Section 4.4.3);

- The monitoring layer (Section 4.4.3);
- The presentation layer; and
- The users.

The BI framework consists of the five different layers proposed by Muntean et al. (2013). These layers are the data layer, the reporting layer, the analytical layer, the monitoring layer and the presentation layer. The Muntean et al. (2013) framework is extended to include additional components, namely the users and the sustainability data landscape.

At the lowest level of this framework is the data layer consisting of the university data warehouse that will be used to store all data relating to sustainability. HEIs also make use of a number of independent transactional systems, each with its own data stores (Kourentzes et al., 2014). Because of the broad nature of sustainability, a large number of these operational data sources will be integrated into a single data warehouse. The data warehouse will also have independent data marts that will make the querying of the data warehouse and analytical processes more efficient. The benefits that can be realised in the data layer include the enhancement of data quality and consistency as well as cost savings as data marts can be consolidated.

The reporting layer will consist of ad-hoc querying as well as the production of static reports. The capabilities of this layer are those of traditional BI. Users can create queries to find information that they require to answer a specific question. Users can also generate reports in order to share the information that has been discovered. These reports are considered static, however, as they will not update as organisational information on the data layer changes. These capabilities enable an organisation to have access to more and better information, which can improve operational performance.

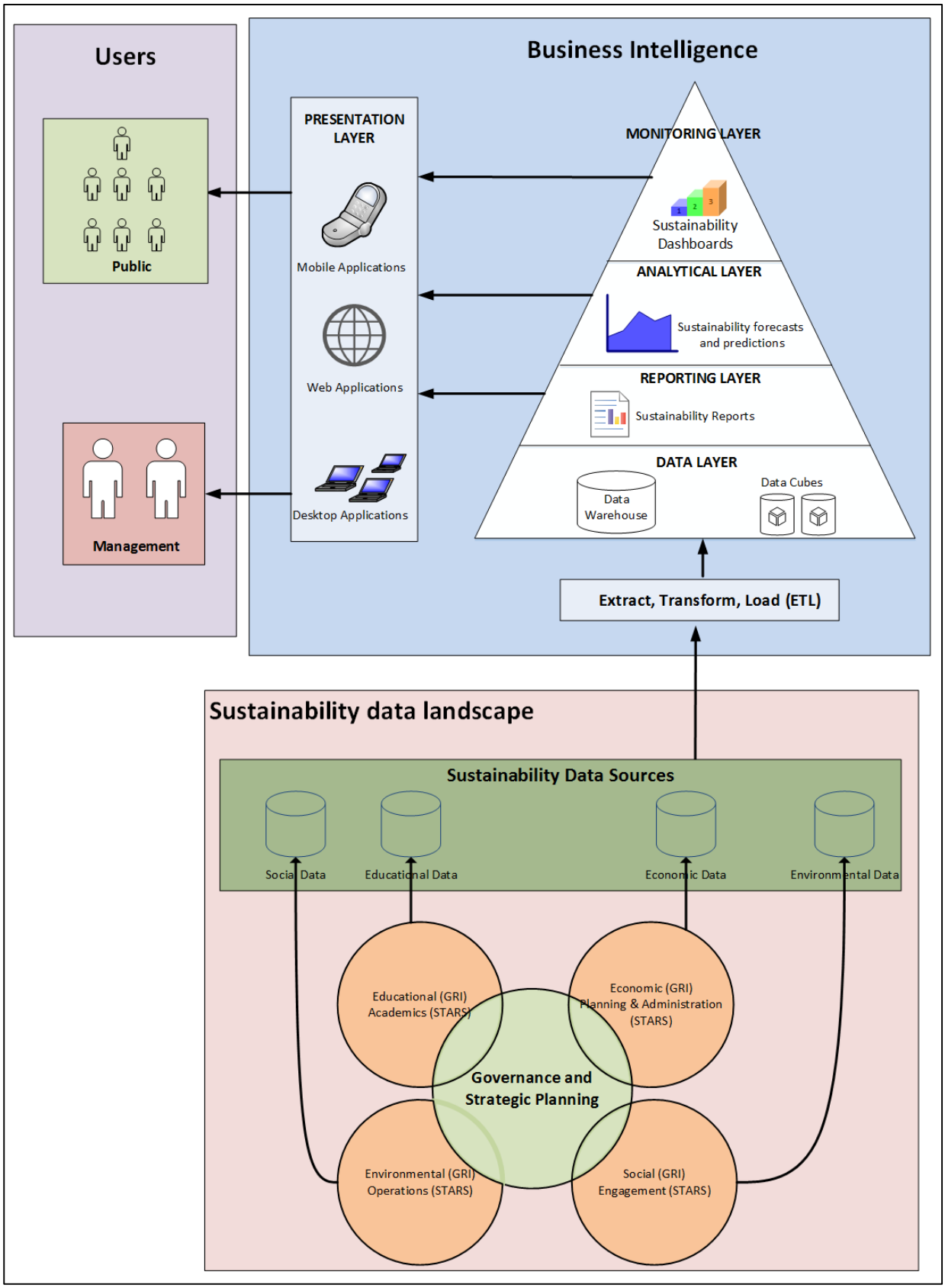

Figure 4-16: BI Framework for strategic sustainability information management in higher education (version 2) (Author's own construct)

On top of the traditional BI components are the new BA components. These new BA capabilities are the analytical and the monitoring capabilities (Section 4.4.3). The analytical layer is a behind-the-scenes layer, in which analytical tools are used to find patterns and trends in the data. The tools that can be used to do this are OLAP, data mining, forecasting and predictive modelling. These capabilities can assist an organisation improve its decision-making qualities as the organisation will know with reasonable certainty what effect a decision will have on the sustainability of an organisation. The monitoring layer consists of performance dashboards and scorecards. These tools enable an organisation to better manage and monitor their sustainability KPIs by providing real-time up-to date information to an organisation's management.

The presentation layer is the platform through which the users, both internal management and external stakeholders, access the information provided by the other layers. This can be through mobile applications, desktop applications or web applications. As management receives the information provided by the BI system, the organisation can determine if it is are on-track to meet the long-term goals identified in the organisational strategy (Section 3.2). The process of receiving information and making decisions based on the organisational strategy is a continuing cycle.

4.12 Conclusions

Sustainability management has become a strategic priority of many organisations, including HEIs. The tools to assist strategic sustainability information management, especially in South African HEIs, are limited. Literature has proposed BI as one of such tools that can assist in the management of the information component of sustainability. A BI framework was proposed that consists of multiple layers (Figure 4-16). At the strategic level, the focus is on the analytical and monitoring layers, as this is the information required by strategic management to effectively manage sustainability.

The BI framework can be used as a theoretical foundation for the implementation of a BI solution to effectively manage strategic sustainability information in HEIs. Before a BI solution can be implemented however, the objectives and requirements of the BI solution should be identified. Through an analysis of existing literature and interviews conducted with the relevant stakeholders at NMMU, the objectives and requirements for a BI solution to support effective sustainability information management were identified (Section 4.10). Comparing the existing

BI system at NMMU to the identified requirements revealed that some of the requirements were not met. Therefore a new BI solution is required if the management of strategic sustainability information at NMMU is to be improved.

This chapter focussed on answering three research questions, namely:

- RQ_4: What are the benefits and challenges of BI?
- RQ_5: What are the critical success factors (CSFs) of a BI project?
- RQ_6: What are the requirements of a BI solution to support effective strategic sustainability information management in HEIs?

By answering these questions, four deliverables were produced. The deliverables are the benefits and challenges of BI, the CSFs of BI, the objectives and requirements of the BI solution, and the BI framework to support effective strategic sustainability information management in HEIs. The BI framework identified the different layers required for BI, the benefits provided by each layer, as well as the outputs that can be produced from each layer. The focus of strategic sustainability management will be on the analytical layer and monitoring layer as the information required by strategic management will be produced in these layers. The next chapter addresses the design and development of the BI solution.

Chapter 5. Design and Development of the BI Solution (Sustainable BI)

5.1 Introduction

BI provides many of the capabilities required to overcome the challenges with sustainability information management (Chapter 4). In order to effectively manage something, management must be able to measure and monitor it with quantifiable metrics. At the strategic level of HEIs, managers require a performance management tool to assist in managing sustainability. The monitoring layer of BI, which uses dashboards and scorecards to represent the status of metrics and KPIs, provides an organisation with the capabilities to monitor and therefore better manage sustainability.

This chapter addresses the design and development activity in the DSR methodology (Figure 5-1). A BI solution to support strategic sustainability management was developed, and can be considered the artefact in this research. The research question that this chapter seeks to answer is:

RQ_7: How should a BI solution to support strategic sustainability information management solution be designed and evaluated?

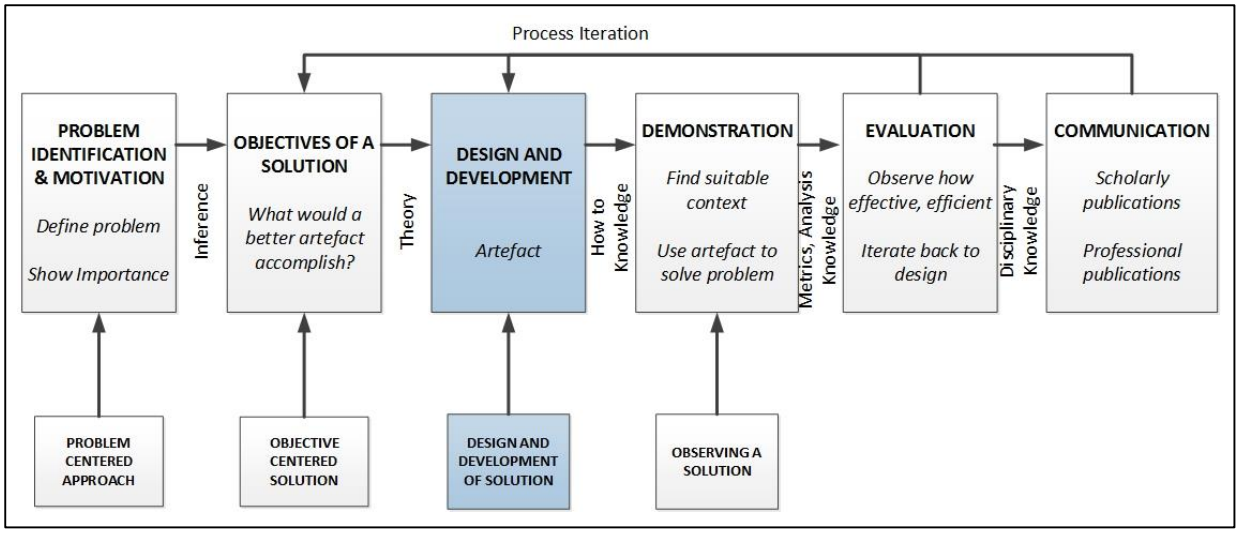

Figure 5-1: Design and development stage of DSR (Peffers et al., 2006)

In order to determine how effective a BI solution is in managing strategic sustainability in HEIs, an evaluation will be conducted. The evaluation plan outlines how the two evaluations in this study will be conducted (Section 5.2). The first evaluation will evaluate the Sustainability Management Model through interviews with the relevant stakeholders at NMMU. The second evaluation will involve the evaluation of Sustainable BI. The findings of the first evaluation are then presented as these need to be considered for the design and development of Sustainable BI (Section 5.3). The design considerations that should be taken into account for the design and development of Sustainable BI are identified (Section 5.4). The architecture upon which Sustainable BI is based is then illustrated (Section 5.5), followed by the development of Sustainable BI (Section 5.5). The extent to which Sustainable BI has fulfilled the objectives and functional requirements of a BI solution to support strategic sustainability information management is outlined (Section 5.7). Conclusions are then drawn based on the findings of the chapter (Section 5.8). The full outline of the chapter is illustrated in Figure 5-2.

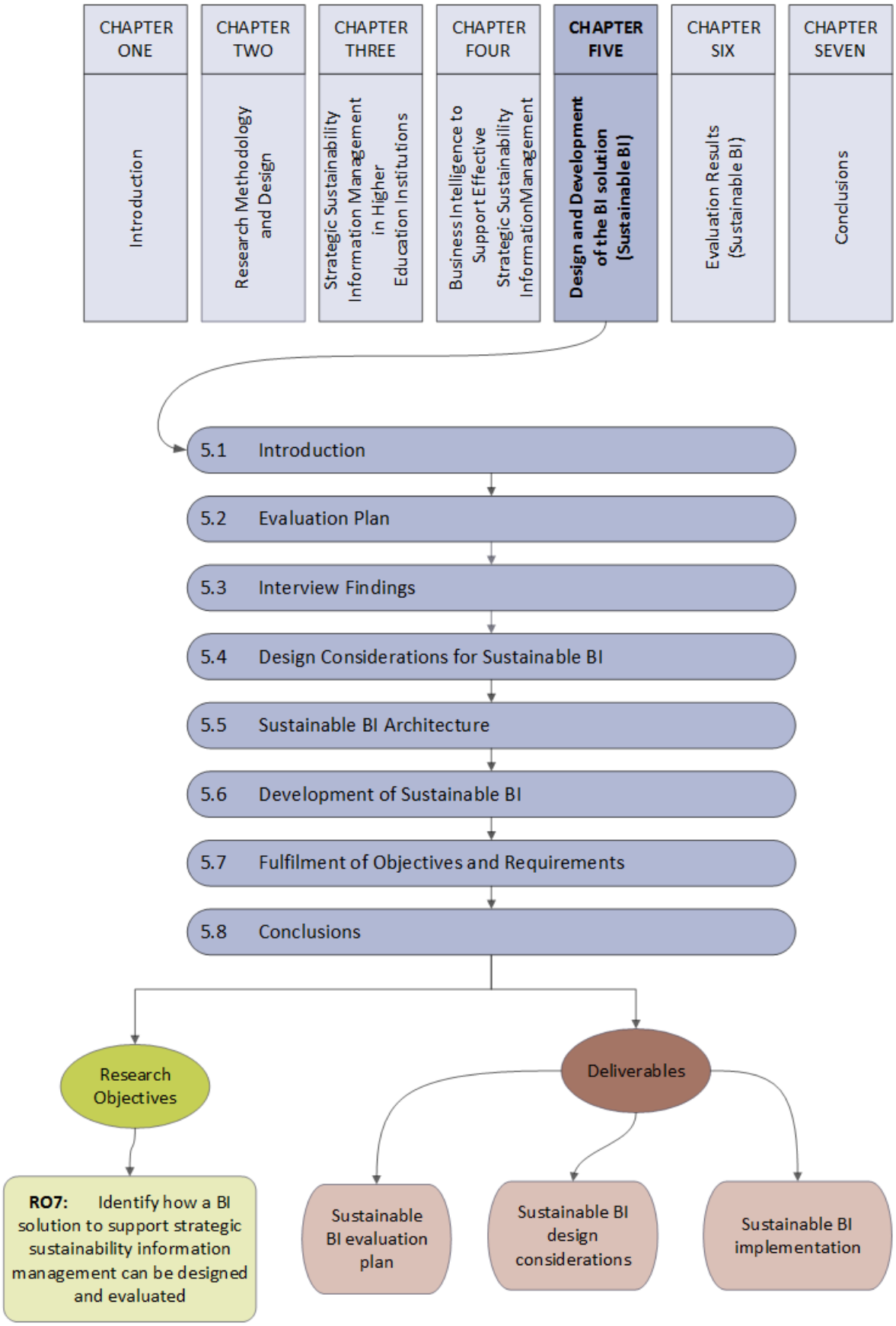

Figure 5-2: Chapter 5 layout

5.2 Evaluation Plan

Both the artefacts produced in Chapter 4, the Sustainability Management Model and the BI framework to support effective strategic sustainability information management in HEIs, should be evaluated. The BI framework will not be evaluated specifically, however the implementation of a BI solution, based on the proposed framework will be evaluated. The process for the evaluation, design and development of the solution to the problem is identified (Figure 5-3).

Two separate evaluations will be conducted in this study. The evaluation plan includes the methods to be followed in the evaluations, as well as the participants that will take part in the evaluations. The first evaluation involves evaluating the Sustainability Management Model (Section 5.2.1). The second evaluation involves evaluating the proposed BI solution, Sustainable BI (Section 5.2.2). The Sustainable BI model will be evaluated prior to the design and implementation of Sustainable BI, as the model should be considered before undertaking a project to more effectively manage sustainability. Once the model has been evaluated, the Sustainable BI Prototype One will be designed and developed. Upon completion of the development of Sustainable BI Prototype One, a heuristic evaluation will be conducted. Changes recommended in the heuristic evaluation will be implemented, leading to the development of Sustainable BI Prototype Two. Sustainable BI will then undergo a full usability evaluation to determine to what extent the proposed solution can overcome the identified problem. Thereafter any recommendations made in the full usability evaluation will be implemented, leading to the development of Sustainable BI Prototype Three.

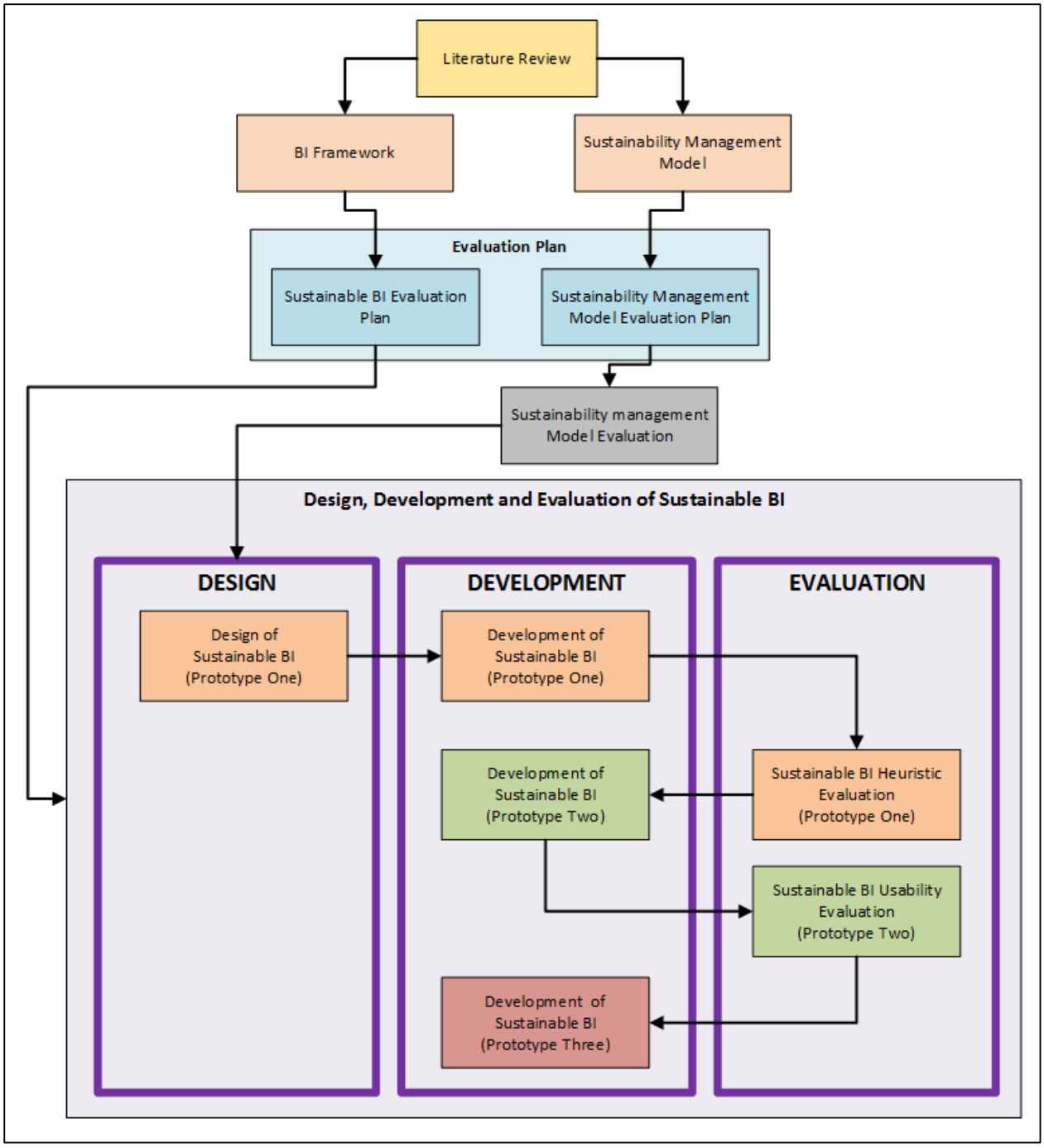

Figure 5-3: Design, development and evaluation process (Author's own construct)

5.2.1 Sustainability Management Model Evaluation Plan

The Sustainability Management Model will be validated through interviews with the relevant stakeholders at NMMU. The model consists of six components, of which three will be validated in the interviews (Table 5-1). The three components that will be validated are the information and IS constraints to effective sustainability management, the BI challenges and the CSFs of

BI. The interviewees will be required to rank the information and IS constraints, the challenges of BI and the CSFs of BI, based on the extent to which they apply at NMMU. The information and IS constraints to effective sustainability management will be validated as these are the constraints which this research focusses on overcoming. It is therefore important to gain an understanding as to what the biggest information and IS constraints are at NMMU so that the researcher can gain an understanding of which constraints need addressing the most. The challenges of BI will be validated as the researcher needs to gain a better understanding of what challenges need to be overcome at NMMU if an effective BI solution is to be implemented. The CSFs for implementing a BI solution will be validated as it is important that the researcher gains a better understanding of what should be done in order to deem a BI solution successful at NMMU.

Table 5-1: Components of Sustainability Management Model validated in interviews

Component of Model	Validated in Interviews
SUSTAINABILITY	
Sustainability drivers	✗
Information and IS constraints	✔
Management and people constraints	✗
BUSINESS INTELLIGENCE	
BI challenges	✔
BI benefits	✗
CSFs of BI	✔

The three components that will not be validated as part of the interviews are the sustainability drivers, the management and people constraints to effective sustainability management and the benefits of BI. This research focusses on addressing the challenges with managing the strategic sustainability information and therefore the sustainability drivers and the management and people constraints to effective sustainability management will not be verified as they fall out of the scope of this research. The benefits of BI will not be validated as these will in no way

affect the implementation of BI solution to overcome the challenges to effectively managing sustainability information.

All interviews will be conducted on a one-on-one basis. The interviews will be conducted with five participants (Table 5-2). Three participants (P1 to P3) all fall under the NMMU Office for Institutional Planning, which is responsible for the management of sustainability at NMMU. P1, P2 and P3 are also actively involved in the development of the NMMU InfoPoint BI solution, have knowledge of both sustainability management at NMMU, as well as BI at NMMU. P1, P2 and P3 will therefore be asked to rank the information and IS constraints at NMMU, the BI challenges at NMMU, and the CSFs for BI at NMMU.

Table 5-2: Interview participants

Participant No.	Participant Job Description
P1	Senior MIS Analyst in the office for institutional planning at NMMU. Responsible for delivering BI solutions. Works directly with P2 and P3.
P2	Director of Transformation, Monitoring and Evaluation at NMMU. Custodian of InfoPoint BI solution delivered by P1. Responsible for all reporting process, including sustainability reporting, at NMMU. Works directly with P1 and P3.
P3	Director of Management Information at NMMU, the department responsible for delivering InfoPoint BI solution. Works directly with P1 and P3.
P4	Senior Manager of MIS at NMMU ICT services. Responsible for delivering BI solutions.
P5	Senior Manager at NMMU ICT services. Responsible for delivering BI solutions.

Participants P4 and P5 are members of the ICT Services Department at NMMU, and are therefore responsible for the technical implementation of BI at NMMU. Because P4 and P5 are not involved in the management of sustainability at NMMU, they will not be required to rank the information and IS constraints to effectively managing sustainability at NMMU. P4 and P5 will only be required to rank the BI challenges at NMMU and the CSFs for BI at NMMU.

5.2.2 Sustainable BI Evaluation Plan

A BI framework for supporting strategic sustainability information management was proposed based on an analysis of existing literature (Figure 4-16). In order to overcome the constraints faced by NMMU in the management of sustainability information at the strategic level, a BI solution is required. A BI solution, Sustainable BI, will be implemented based on the proposed BI framework. The objectives of the BI solution, were identified in Chapter 4. In order to

determine to what extent the identified solution solves the identified problem, the developed artefact will require a usability evaluation.

5.2.2.1 Sustainable BI Heuristic Evaluation

A heuristic evaluation is an informal usability evaluation in which users are required to comment on a given system according to a number of heuristic characteristics (Nielsen and Molich, 1990). A heuristic evaluation enables the developer to gain an understanding of the usability issues during the development of the system (Nielsen and Molich, 1990; Oracle, 2012). The advantage of a heuristic evaluation over a full usability study is that it is quicker to run. A heuristic evaluation will be conducted upon completion of the first prototype of Sustainable BI in order to fix any usability issues before the development of the second Sustainable BI prototype, and the subsequent summative usability evaluation.

5.2.2.1.1 BI Heuristic Criteria

The user in a heuristic evaluation finds usability issues by checking the system against a set of heuristic criteria. Forsell and Johansson (2010) identified ten heuristic criteria specific to information visualisation tools such as performance dashboards (Table 5-3). As users will interact with Sustainable BI through performance dashboards, the identified heuristic criteria should be applied to the design and development of Sustainable BI. The user will be provided with an explanation of the ten heuristics which they should consider when conducting the heuristic evaluation (Appendix C.1).

Table 5-3: Heuristic criteria (Forsell and Johansson, 2010)

Number	Description
H1	Information coding
H2	Minimal actions
H3	Flexibility
H4	Orientation and help
H5	Spatial organisation
H6	Consistency
H7	Recognition rather than recall
H8	Prompting
H9	Removing the extraneous
H10	Data set reduction

An individual's perception of information is directly dependent on the mapping of the information to visual objects such as graphs. Information coding therefore refers to the representation of information by using the correct visual objects. The dashboard should also enable the user to accomplish tasks using the least number of actions possible. All unnecessary actions should be removed. The dashboard should also be flexible by providing the users with multiple ways to accomplish a goal. The dashboard should also provide the user with functions to control the levels of details of information, redo/undo actions and representing additional information. The dashboard should also use space optimally, while ensuring that all information is legible. There should also be consistency in design. Design choices across the entire application should be consistent. The user should also not have to memorise large amounts of information to carry out tasks. All extraneous information that is a distraction and is not required should be removed from the dashboard.

5.2.2.1.2 Heuristic Evaluation Participants and tasks

Nielsen and Landauer (1993) and Nielsen (1992) argue that a heuristic evaluation should be performed by three experts. The heuristic evaluation of Sustainable BI will therefore be conducted by using five participants as this will ensure that most heuristic issues will be found. The participants will consist of Masters and PhD students in the NMMU Computing Sciences department. The participants will be selected based on their BI experience. The selected participants will all have more than two years' experience and can therefore be considered as experts.

Each participant will be provided with a task list outlining the tasks that the participant will be required to complete (Appendix C.2). As each participant in the heuristic evaluation can be considered a BI expert, the task list will not be too detailed. The tasks in the heuristic evaluation will cover the broad functionality of Sustainable BI (Section 4.10), and will include:

- Navigating Sustainable BI (R1-R9);
- Filtering information using filters (R2);
- Filtering information using visualisations (R2);
- Drilling-up and drilling-down of information (R4);
- Predicting future outcomes using forecasting (R5); and
- Creating reports (R6).

5.2.2.2 Sustainable BI Usability Evaluation

The objective of the BI solution is to support effective strategic sustainability management. Usability can help determine if a software product is easy to learn, effective to use and enjoyable for the user. This culminates in the goals of effectiveness, efficiency, learnability and memorability (Jooste, Van Biljon and Mentz, 2014).

5.2.2.2.1 Evaluation Objectives

To determine to what extent Sustainable BI can solve the identified problem, a full usability evaluation is required. A BI solution, Sustainable BI, is proposed to assist strategic management in HEIs with managing sustainability information more effectively. Usability is the extent to which a given system, product or service can be used by a given set of users to achieve specific goals with efficiency, effectiveness, satisfaction in a specified context of use (ISO 9241-210, 2010). A usability evaluation, therefore, provides a platform to determine if BI can support more effective sustainability information management.

5.2.2.2.2 Task List

During the evaluation, participants will be required to perform a number of tasks using Sustainable BI (Appendix C). During the tasks, participants will be required to answer a number of questions relating to the tasks. Upon completion of the designated tasks, participants will be required to complete a questionnaire.

The task list for the evaluation consists of six broad tasks:

- Navigating Sustainable BI (R1 - R9);
- Filtering information using filters (R2);
- Filtering information using visualisations (R2);
- Drilling-up and drilling-down of information (R4);
- Predicting future outcomes using forecasting (R5); and
- Creating reports (R6).

The tasks that the participants will perform in the usability evaluation cover the nine broad functions (R1 - R9) of sustainable BI (Section 4.10). Filtering will enable the participant to

select certain information based on specific criteria. Drilling-down and drilling-up will enable the participant to view information from different levels of detail. Forecasting will enable the user to predict future outcomes based on historic data, and creating reports will enable the participants to share information with other people.

5.2.2.2.3 Research Materials

As part of the evaluation, a number of research materials will be used (Table 5-4). In order to participate in the evaluation, users will be required to sign a consent form, in which participants agree to the conditions of the evaluation. No data analysis will be performed on the data collected by these consent forms. Participants will also be required to complete a biographical questionnaire. Quantitative statistical analysis will be performed on the data collected by this questionnaire. Instructions for the evaluation will be provided to the participants through a written information form and a task list.

Table 5-4: Research material used in the usability evaluation

Material Description	Data Analysis	Type
Biographical questionnaire	Quantitative statistical analysis	Demographic
Consent form	No analysis	Instructions
Written information given to participants		
Task list		
Post-test questionnaire	➢ Qualitative thematic analysis ➢ Quantitative statistical analysis	Research Instrument

5.2.2.2.4 Participant Selection

The participants in a usability evaluation should be representative of the actual users of the system being evaluated. For the purpose of this evaluation, strategic management at NMMU will be used. The participants will all be members of the NMMU MANCO, the strategic management at NMMU. The Office for Institutional Planning is directly responsible for the management of sustainability at the strategic level. The Office for Institutional Planning is subdivided into six separate departments, namely:

- Strategic Planning and Institutional Research;
- Management Information;

- Transformation, Monitoring and Evaluation;
- Quality Advancement;
- Academic Planning; and
- Centre for Integrated Post-School Education & Training.

Selected staff members in these departments will be invited to participate in the usability evaluation. Certain members of NMMU MANCO have an indirect interest in the management of strategic sustainability at NMMU and include deans of faculties, the international office and deputy vice-chancellors. These members will also be invited to participate in the evaluation.

Traditionally it was believed that five participants in a usability evaluation was enough to determine any major issues and determine whether the system was suitable or not (Lewis, 1991; Nielsen and Landauer, 1993). More recent literature however, has revealed that five participants is not adequate and that 10 to 12 participants is more desirable (Lindgaard and Chattratichart, 2007; Tullis and Albert, 2013). For the purpose of his evaluation, 12 participants will be used to ensure that all usability issues are identified.

5.2.2.2.5 Evaluation Metrics

The goal of any usability evaluation is to measure the success of a particular system. In order to do this, a number of metrics need to be used in order to quantify the extent to which a system solves a given problem. Usability can be defined as "*the degree to which the software product can be understood, learned, used and is attractive to the user, when used under specified conditions*" (ISO, 2008). Some of the more common usability metrics are:

- Effectiveness;
- Efficiency;
- Satisfaction;
- Ease of use;
- Learnability;
- Understandability;
- Number of Errors;
- Accuracy; and
- Usability (operability).

Effectiveness refers to the extent to which the software can allow a user to accurately complete a given task (Preece, Rogers and Sharp, 2011). Efficiency is the degree to which the product performs as expected enabling users to complete their task successfully (Tullis and Albert, 2013). Efficiency can be quantified as the amount of effort required by users to complete a given task (Rubin and Chisnell, 2008). Satisfaction is the perceived happiness experienced by the user when completing a given task. Satisfaction is subjective and can be measured by asking users questions about their experience with the system. Ease of use refers to the extent to which the software makes it easy to use the software. Learnability refers to the extent to which the software enables users to learn the application. Understandability refers to the ability of the software to enable users to understand the functionality of the system and whether it is appropriate for a given set of tasks. Usability refers to the ability of the software to enable users to control and operate it. The term usability has been replaced by operability in many studies. The effectiveness, efficiency, usability, and learnability metrics map directly to the non-functional requirements identified for a BI solution to support strategic sustainability information management.

Jooste et al. (2014) identified five metrics that can be used for a BI usability evaluation. The five BI metrics are visibility, flexibility, learnability, error control and help, and operability. A comparison of the Jooste et al. (2014) metrics to the common metrics identified by ISO (2008), reveals that the metrics are very similar, with slight differences (Jooste et al., 2014). Learnability and operability correspond directly, whereas error control and help correspond to understandability (Jooste et al., 2014). As the Jooste et al. (2014) metrics are highly relevant to the BI solution, these metrics will be used in the evaluation of Sustainable BI. The metrics of effectiveness and efficiency will be added as these two metrics are relevant for any IT application (Tullis and Albert, 2013).

5.2.2.2.6 Post-Test Questionnaire

Upon completion of the usability evaluation, participants will be required to complete a post-task questionnaire (Appendix D.2). The questionnaire contains a number of statements, to which the participants are required to respond through a 5 point Likert scale, to what extent they agree with the statement. The statements are broken into seven categories.

The first five categories are the usability metrics identified by Jooste et al. (2014), namely:

- Visibility;
- Flexibility;
- Learnability;
- Error control and help; and
- Operability.

Categories six and seven cover two additional categories, namely:

- Efficiency; and
- Effectiveness.

The questionnaire also has a section on biographical information and a section with open ended questions where users can give more extensive feedback.

5.3 Interview Findings [1]

The analysed literature highlights the constraints to managing sustainability information and proposes BI as a solution to the problem. Structured interviews were conducted with key personnel at NMMU to determine the biggest constraints to effectively managing sustainability information at NMMU (Section 5.3.1), the challenges with implementing a BI solution at NMMU (Section 5.3.2), and the factors that are deemed critical to the success of a BI project (Section 5.3.3). The interviews were conducted with those responsible for the management of sustainability at NMMU, Management Information Systems (MISs) analysts at NMMU and BI developers at NMMU. The findings of the interviews will contribute to the design of Sustainable BI, as researcher can gain a better understating of the constraints the solution needs to overcome, as well as should be done in order to develop a successful system.

5.3.1 Constraints to Effective Sustainability Information Management at NMMU

Like HEIs globally, NMMU is constrained in effectively managing its sustainability initiatives. Literature revealed a number of constraints to effectively managing sustainability (Section 3.8).

[1] Interview results published in paper for the 2015 Annual Conference of the South African Institute of Computer Scientists and Information Technologists (SAICSIT) (Appendix E)

Strategic management responsible for managing sustainability initiatives and providing detailed reports on these initiatives were provided with a questionnaire in which they were asked to rank the constraints to effective sustainability management based on the extent to which it is a constraint at NMMU (Table 5-5). The focus is purely on the five data and information constraints as the purpose of this study is to overcome these constraints through the use of an integrated IS.

Table 5-5: Constraints to effectively managing sustainability information at NMMU [2]

Constraints to Effective Sustainability Management	**Rank**	**Mean Ranking (μ)**
Siloed data and information	1 (P1, P2), 2 (P3)	1.3
Poor sharing and communication of information	1 (P3), 2 (P2), 3 (P1)	2
Lack of sustainability data access	2 (P1), 3 (P2, P3)	2.7
Overlapping of data (Data is recorded by multiple times)	4 (P1, P3), 5 (P2)	4.3
Unavailability of data	4 (P2), 5 (P1, P3)	4.7

The analysis of the interview data revealed that the biggest constraint to effectively managing sustainability at NMMU is siloed data and information. The diverse nature of sustainability means that data is often recorded by multiple departments in multiple data sources. This siloed data and information also leads to poor sharing and communication of information, which is the second biggest constraint to effectively managing sustainability at NMMU. The third biggest constraint is the lack of sustainability data access. Because data is siloed, management cannot always access the necessary data when required. The overlapping of data and the unavailability of data are the two least constraining factors at NMMU. The ranking of constraints highlights that siloed data is the biggest constraint to effective sustainability information management, and therefore a more integrated approach is required. Whist BI is one IS that can overcome the issues of siloed data and information, at NMMU there are

[2] Constraints are ranked from 1 - 5 (1 – biggest constraint)

multiple, unintegrated BI systems, responsible for the management of individual areas of sustainability.

5.3.2 BI Challenges at NMMU

NMMU, similar to other organisations, encountered challenges in the implementation of their BI solutions (Table 5-6). An analysis of existing literature found that there is a number of challenges to implementing a BI solution successfully (Section 4.5). These challenges need to be overcome to ensure that the BI solution serves as an effective mechanism for managing sustainability information. Interviewees were requested to rank the challenges, based on what they have experienced, as the biggest challenges to implementing a BI solution at NMMU.

Table 5-6: BI challenges at NMMU [3]

BI Challenge	Rank	Mean Rank (μ)
IT support	1 (P1, P3, P4), 2 (P5), 4 (P2)	1.8
Organisational alignment	1 (P2, P5), 2 (P1), 3 (P4), 4 (P3)	2.2
Complexity of BI tools	2 (P2, P3), 3 (P1), 4 (P4), 5 (P5)	3.2
High cost	2 (P4), 3 (P3, P5), 4 (P2), 5 (P1)	3.4
Data quality	3 (P2), 4 (P1, P5) 5 (P3, P4)	4.2

The results of the interviews revealed that providing IT support to management using the BI system was the biggest challenge with implementing a BI solution. IT departments at HEIs are typically understaffed and therefore providing immediate assistance is not always possible. Aligning the BI system with organisational goals and objectives was highlighted as the second biggest challenge to implementing a BI solution at NMMU. The complexity of the BI tools is the third biggest challenge with implementing a BI solution at NMMU, followed by the high costs of both the software and implementation thereof. The least challenging factor is the quality of data. Transactional systems responsible for recording data, have been implemented correctly ensuring data accuracy, completeness and consistency.

[3] Challenges are ranked from 1 - 5 (1 – biggest challenge)

5.3.3 CSFs for BI at NMMU

Literature has identified a number of factors that are critical for the success of a BI project (Section 4.6). In order to implement a BI solution to support effective sustainability information management at NMMU it is important the CSFs for a BI project. The five participants ranked each of the CSFs for BI from 1 to 10 (Table 5-7).

Table 5-7: CSFs for BI [4]

Critical Success Factor for BI	Rank	Mean Rank (μ)
Clear vision and well-defined requirements of the BI system	1 (P1, P4), 2 (P5), 3 (P2), 4 (P3)	2.2
Committed management support	1 (P2, P3, P5), 2 (P1),7 (P4)	2.4
Aligning the BI strategy with business objectives	2 (P2, P4), 3 (P1, P3, P5)	2.6
Committed and informed executive sponsor	4 (P1, P4, P5), 5 (P2), 6 (P3)	4.6
Appropriate team skills	2 (P3), 6 (P1, P4), 8 (P2, P5)	6
Adequate resources (Including financial, human capital etc.)	5 (P1, P4), 6 (P5), 8 (P3), 9 (P2)	6.6
Effective data management	5 (P3, P5), 7 (P1, P2), 10 (P4)	6.8
User-oriented change management	3 (P4), 4 (P2) 9 (P1, P5), 10 (P3)	7
Project scope management	6 (P2), 7 (P3, P5), 9 (P4), 10 (P1)	7.8
Flexible and appropriate framework	8 (P1, P4), 9 (P3), 10 (P2, P5)	9

The participants identified the important role that a clear vision and well defined requirements for the BI solution play in a successful project as this was ranked the most important CSF. Other highly ranked CSFs were committed management support and aligning the BI strategy with the business objectives.

[4] CSFs are ranked from 1 – 10 (1 –factor most critical for success)

5.4 Design Considerations for Sustainable BI

The focus of Sustainable BI, the proposed BI solution to be developed in this industry, is to provide the relevant sustainability information to strategic management. Sustainable BI will be designed and developed based on the proposed BI framework to support strategic sustainability information management (Figure 4-16). Because the focus of this study is managing information at the strategic level, the focus will be on optimising the design of the strategic BI capabilities, which are contained in the analytical and monitoring layers of the BI framework. Sustainable BI will be developed on top of an existing data infrastructure.

The required information will be provided to management in the form of dashboards. Tullis and Albert (2013) identify three design considerations that are highly relevant to dashboards (O'Donnell and David, 2000). These three implications are:

1. The interaction and feedback given by the system.
2. The presentation format to be used.
3. The differences in the amount of information provided.

Dashboards should enable managers to easily identify trends, patterns and anomalies in information (Yigitbasioglu and Velcu, 2012). This heightens the importance of the visual information design. A study by Pauwels et al. (2009) highlighted a number of common pitfalls that occur in the design of dashboards. The development of the dashboards as part of the BI solution will attempt to avoid these pitfalls. The pitfalls identified by Few (2006b) are:

- Displaying excessive detail or precision;
- Choosing inappropriate media to display data;
- Arranging the information poorly;
- Overuse of colour;
- Ineffectively highlighting what is important; and
- Designing an unappealing visual display.

Because dashboards are used to support rapid monitoring, they should not provide excessive detail that makes it difficult for users to find the required information. Dashboards should also not provide too much precision as it also makes finding information difficult. One of the most

common mistakes when presenting information is the use of incorrect media (Juice Analytics 2009; Few 2006b). Developers often make the mistake of displaying information in a graph when a table wold be better suited or vice versa. Developers also make the mistake of using the inappropriate type of graph to display information. Juice Analytics (2009) provides suggested graph types for different information and data (Figure 5-4).

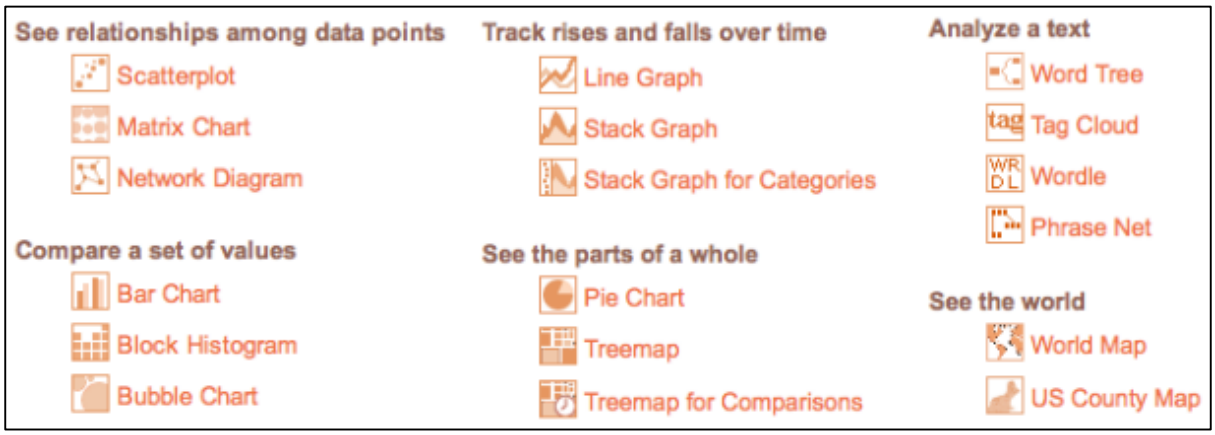

Figure 5-4: Suggested graphs for dashboards (Juice Analytics, 2009)

Information in a dashboard should be arranged in a clear and logical manner. Information that is most important should be placed in an area of the dashboard that is most prominent. Colour should be used to highlight important information and not to make the dashboard more aesthetically pleasing. One of the biggest mistakes that dashboard developers make is the overuse of bright colours on a dashboard (Few, 2006b; Juice Analytics, 2009). This makes it difficult for users to identify information that requires critical attention. The correct use of colour can help identify important information. Like any computer system, aesthetics play an important role. A dashboard should be aesthetically pleasing and encourage users to make use of the system.

5.5 Sustainable BI Architecture

The BI solution to be developed will be based on the BI framework to support strategic sustainability information management (Figure 4-16). The BI solution, Sustainable BI, will make use of an existing BI tool to develop a BI solution to support strategic sustainability information management in South African HEIs. The solution will be developed for NMMU, the case study for this research. Interviews with the relevant stakeholders at NMMU revealed a number of problems with sustainability management and the implementation of BI systems

at NMMU. The biggest challenges with the management of sustainability information were siloed data and information and poor sharing of information. Software systems, including BI, are developed in isolation by different departments for their specific needs, and therefore only cover specific aspects of sustainability, while some aspects of sustainability, such as the environmental aspect, are not covered by any systems. Sustainable BI will provide an integrated approach to sustainability information management.

The Sustainable BI architecture (Figure 5-5) is based on the proposed BI Framework (Figure 4-16). The BI architecture consists of all the different components identified in the framework. The components are the operational data sources, the ETL process, the data layer, the reporting, analytical and monitoring layer, and the presentation layer. The data sources, ETL processes, data warehouses and data cubes have already been created in isolation by various departments at NMMU. Because the data cubes have already been created, these will be used for the data analysis and presentation. The architecture on which Sustainable BI is developed will make use of data that covers more than one category of sustainability.

Sustainable BI will use a combination of Microsoft and Tableau technologies. Microsoft SQL Server will be used as the data platform as this is the platform used at NMMU, and NMMU students have access to an existing SQL Server implementation. Tableau does not provide a data platform and therefore needs to be built on top of an existing data platform.

A combination of tools will be also be used in the reporting, analytical and monitoring layer. Sustainable BI enables the creation of both CSV reports, which can be viewed in Microsoft Excel, and PDF reports which can be viewed in a PDF readers such as Adobe Acrobat reader. While Tableau does enable the creation of predictive models, the predictive capabilities of tableau are limited and therefore a more advanced analytical tool is required. The statistical program R will be used to create predictive models as tableau provides easy integration with R. The dashboards that will be used to visualise the information will all be created using Tableau. The dashboards can be accessed by the users in the presentation layer through Tableau's online cloud platform, Tableau Online. According to Gartner's (2014) Magic Quadrant for BI vendors, Tableau is a leader in BI software. Tableau also provides students with a free one-year licence.

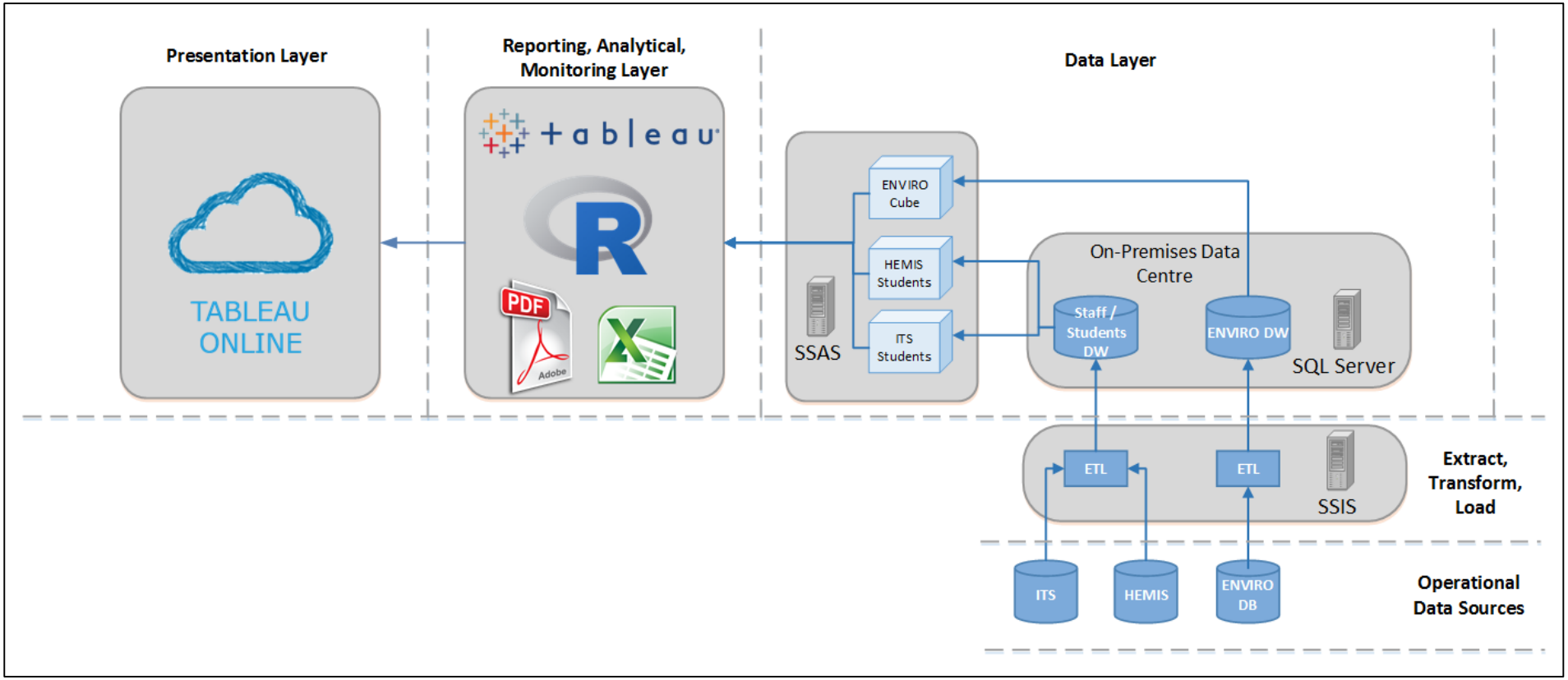

Figure 5-5: Sustainable BI architecture (Author's own construct)

5.6 Development of Sustainable BI

The capabilities that strategic management require from a BI solution were identified (Section 4.10). Using the identified criteria, Sustainable BI was developed. Sustainable BI obtains its data from the data layer (Section 5.6.1). A number of strategic capabilities are provided by Sustainable BI to enable management to better analyse and manage strategic sustainability information (Section 5.6.2). Sustainable BI provides information to management through performance dashboards. These dashboards were developed using a six-step process that was previously identified (Section 5.6.3). A number of design criteria were applied to ensure that Sustainable BI avoided the common pitfalls with dashboard development (Section 5.6.4).

5.6.1 Data Layer and Operational Data Sources

Whilst the focus of this research is providing sustainability information to strategic management and not the design of the data layer, it is still important to address the data layer as the information provided by Sustainable BI is entirely dependent on the quality of the data provided. The bottom layer of the architecture is the operational data sources. Due to the time constraints of this project, the operational data sources will be limited to three. The data sources that will be used are the ITS database, the HEMIS database and the ENVIRO database. These data sources cover two categories of sustainability, the educational and the environmental categories. The data from the operational data sources will go through the ETL process, in which the data is extracted from the operational data sources, cleansed and transformed into the required data warehouse format, and then loaded into the data warehouse. The ETL process is performed by using SQL Server Integration Services (SSIS).

Two separate data warehouses will be used, the ENVIRO DW and the Staff/Students DW. The ENVIRO DW contains data from the ENVIRO DB. The Staff/Students DW contains data from both the HEMIS database and the ITS database. The data sources for this study will consist of three SQL Server data cubes created in SQL Server Analysis Services (SSAS). The cubes have been created off an existing SQL Server data warehouse utilised by NMMU. The cubes will consist of student information as well as environmental information.

These cubes were chosen as they cover multiple aspects of sustainability in HEIs, namely the educational and environmental aspects. The three cubes are:

1. the ITS students cube;
2. the HEMIS students cube; and
3. the environmental cube.

The ITS students cube contains data about students at NMMU (Figure 5-6). The data contained in the cube is all data related to student activity. The data includes student application data, student enrolment data, student residence data, student graduation data, and student academic result data. The data contained in the cube is based on the years 2012 to 2015. The total size of the cube is approximately 2GB.

	Award_Year	For...	Post_Graduate_...	Student_Number	Student_Type_Description	Qualification_Description	Approved_Qualification_Description
1	2015	4	Under Graduate	208010463	NORMAL STUDENT	LLB	BACCALAUREUS LEGUM
2	2013	3	Under Graduate	208009773	NORMAL STUDENT	Dip (Human Resource Management)	NATIONAL DIPLOMA: HUMAN RESOURCES MANAGEMENT
3	2014	1	Under Graduate	208010202	NORMAL STUDENT	BTech (Public Management)	BACCALAUREUS TECHNOLOGIAE: PUBLIC MANAGEMENT
4	2014	3	Under Graduate	208010301	NORMAL STUDENT	BA (General) Extended Program	BACCALAUREUS ARTIUM
5	2014	3	Under Graduate	208009830	NORMAL STUDENT	BA	BACCALAUREUS ARTIUM
6	2013	3	Under Graduate	208011090	NORMAL STUDENT	BCom (C2: General Accounting)	BACCALAUREUS COMMERCII
7	2015	1	Post Graduate	208011201	NORMAL STUDENT	MTech (Cost & Management Accounting)	MAGISTER TECHNOLOGIAE: COST AND MANAGEMENT ACCOU...
8	2013	3	Under Graduate	208010153	NORMAL STUDENT	Dip (Human Resource Management)	NATIONAL DIPLOMA: HUMAN RESOURCES MANAGEMENT
9	2013	1	Post Graduate	208011094	NORMAL STUDENT	PG Dip (Financial Planning)	POSTGRADUATE DIPLOMA IN FINANCIAL PLANNING
10	2014	2	Post Graduate	208011277	NORMAL STUDENT	PG Dip (Health and Welfare Management)	POSTGRADUATE DIPLOMA IN HEALTH AND WELFARE MANAGE...
11	2013	1	Post Graduate	208011425	NORMAL STUDENT	BComHons (Accounting)	BACCALAUREUS COMMERCII HONORES
12	2015	2	Post Graduate	208011272	NORMAL STUDENT	MA (Health and Welfare Management)	MAGISTER ARTIUM IN HEALTH AND WELFARE MANAGEMENT
13	2013	1	Under Graduate	208011201	NORMAL STUDENT	BTech (Internal Auditing)	BACCALAUREUS TECHNOLOGIAE: INTERNAL AUDITING
14	2014	1	Post Graduate	208011469	NORMAL STUDENT	PG Dip (Financial Planning)	POSTGRADUATE DIPLOMA IN FINANCIAL PLANNING

Figure 5-6: Graduation data contained in the ITS students DB

The HEMIS students cube contains historic data about students at NMMU (Figure 5-8). Much like the ITS students cube, all the data in the HEMIS students cube relates to student activity. The data is not as diverse as the ITS students cube and consists of data about enrolments, FTEs and student study areas. The timeframe of the data collected is larger, however, and contains data from the year 2005 to 2015. The structure of the HEMIS DW reveals the different data components stored, including data relating to major study areas, FTEs and the headcount of students and NMMU (Figure 5-7).

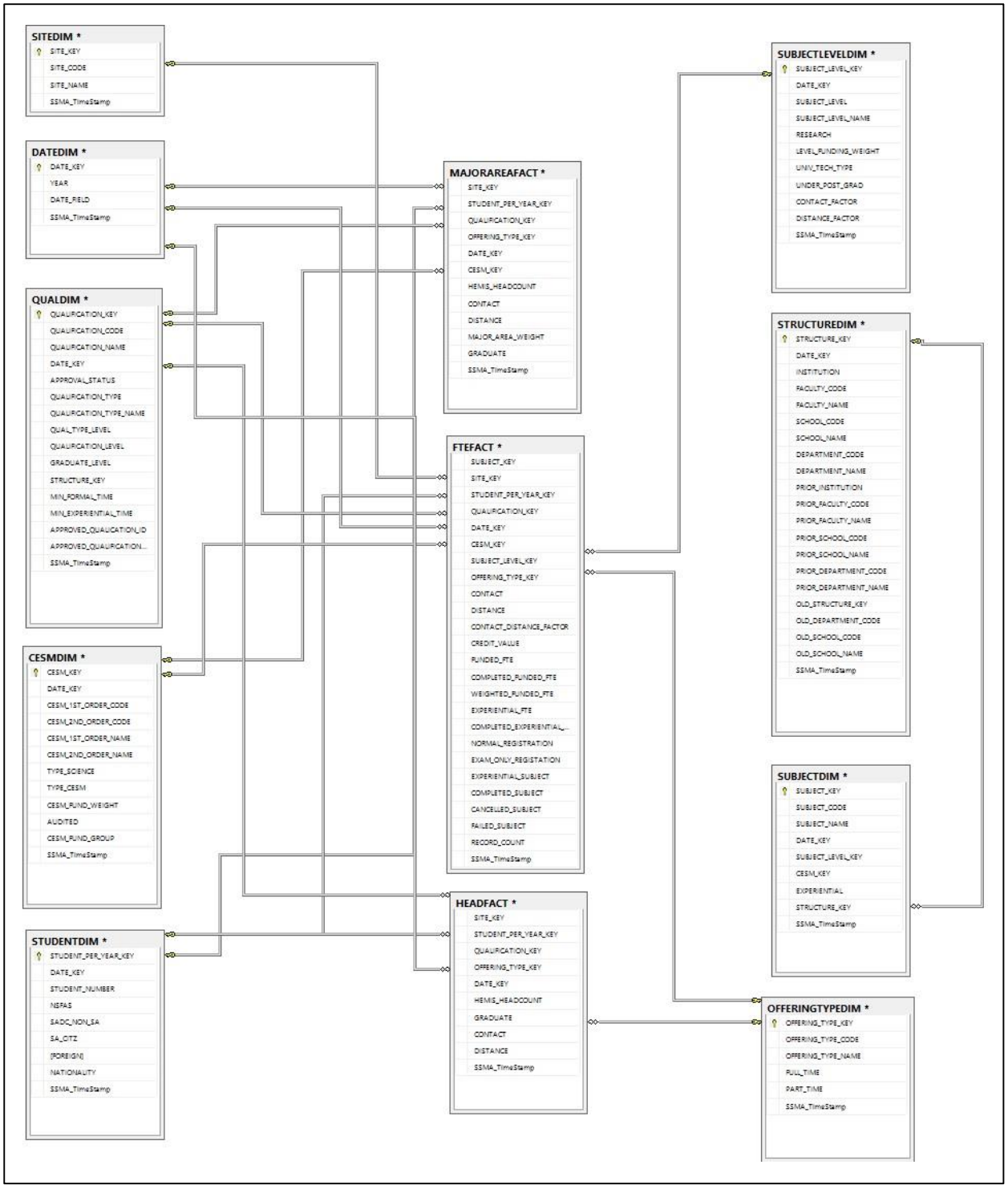

Figure 5-7: HEMIS students DW

	SITE_NAME	YEAR	STUDENT_NUMBER	NATIONALITY	OFFERING_TYPE_NAME	FULL_TIME	PART_TIME	QUALIFICATION_NAME
1	SUMMERSTRAND CAMPUS SOUTH	2001	198173840	South African	FULL TIME SOUTH CAMPUS	F	NULL	BCOM C1 ACCOUNT,BUSS MANAG.&ECONOMICS
2	SUMMERSTRAND CAMPUS SOUTH	2001	198174990	South African	FULL TIME SOUTH CAMPUS	F	NULL	LLB BACCALAUREUS LEGUM
3	SUMMERSTRAND CAMPUS SOUTH	2001	198177240	South African	FULL TIME SOUTH CAMPUS	F	NULL	BA (EC)
4	SUMMERSTRAND CAMPUS SOUTH	2001	198177240	South African	FULL TIME SOUTH CAMPUS	F	NULL	MPHIL (PUBLIC ADMINISTRATION)
5	SUMMERSTRAND CAMPUS SOUTH	2001	198178270	South African	FULL TIME SOUTH CAMPUS	F	NULL	BA HONS BA HONS LABORATORY
6	SUMMERSTRAND CAMPUS SOUTH	2001	198179060	South African	FULL TIME SOUTH CAMPUS	F	NULL	BA HONS BA HONS LABORATORY
7	SUMMERSTRAND CAMPUS SOUTH	2001	198180170	South African	FULL TIME SOUTH CAMPUS	F	NULL	BSC BACCALAUREUS SCIENTIAE
8	SUMMERSTRAND CAMPUS SOUTH	2001	198180780	South African	SOUTH CAMPUS PART-TIME	NULL	P	M.PHIL.
9	SUMMERSTRAND CAMPUS SOUTH	2001	198181820	South African	SOUTH CAMPUS PART-TIME	NULL	P	BCOM C1 ACCOUNT,BUSS MANAG.&ECONOMICS
10	SUMMERSTRAND CAMPUS SOUTH	2001	198182500	South African	SOUTH CAMPUS PART-TIME	NULL	P	BA BACCALAUREUS ARTIUM
11	SUMMERSTRAND CAMPUS SOUTH	2001	198183390	South African	SOUTH CAMPUS PART-TIME	NULL	P	MCUR(CW)MAGISTER CURATIONIS(COURSE WORK)
12	SUMMERSTRAND CAMPUS SOUTH	2001	198184790	South African	FULL TIME SOUTH CAMPUS	F	NULL	LLB BACCALAUREUS LEGUM
13	SUMMERSTRAND CAMPUS SOUTH	2001	198185220	South African	FULL TIME SOUTH CAMPUS	F	NULL	BA HONS BA HONS LABORATORY
14	SUMMERSTRAND CAMPUS SOUTH	2001	198186490	South African	FULL TIME SOUTH CAMPUS	F	NULL	BCOM C3 ACCOUNTING

Figure 5-8: Enrolment data contained in the HEMIS students DW

The environmental cube contains data about the electricity usage and water usage at NMMU (Figure 5-10). The cube contains the total usage for each water and electricity meter for a given month. This meter is linked to a specific building, cost centre and campus (Figure 5-9). The structure of the HEMIS DW illustrates that the information contained relates to the cost centre usage for water and electricity usage at NMMU (Figure 5-7).

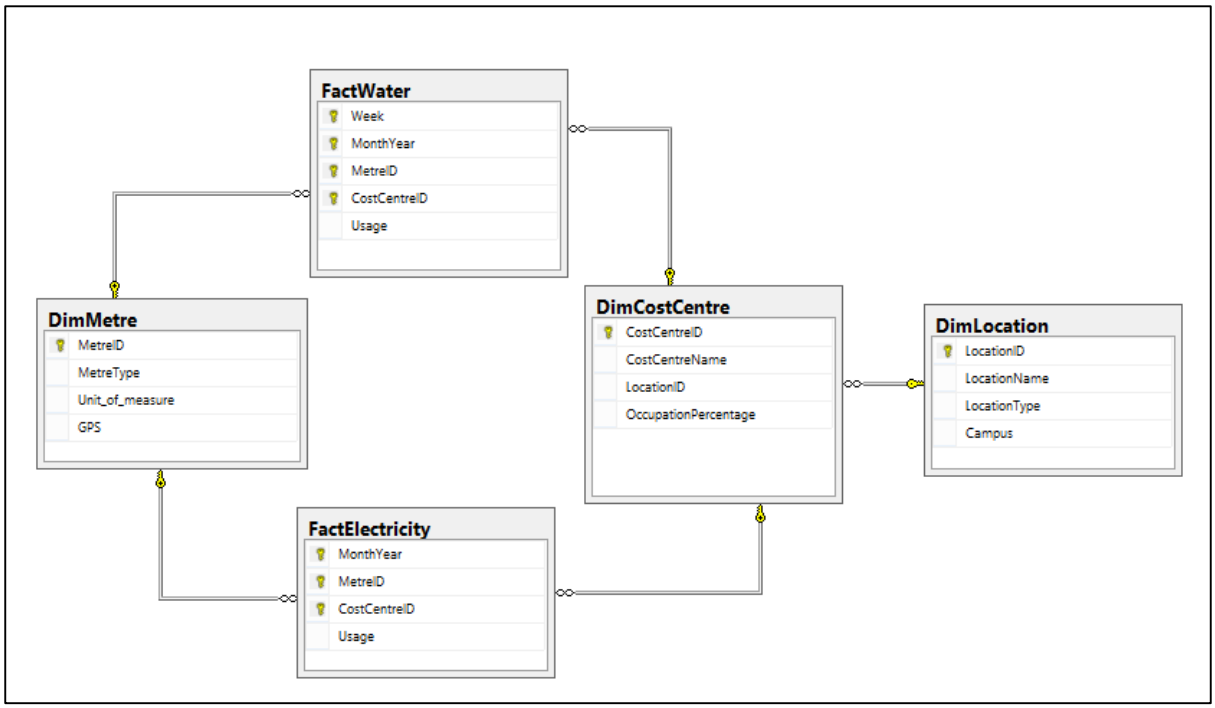

Figure 5-9: Enviro DW

	Campus	CostCentreName	Usage	MetreID	MonthYear
1	SECOND AVENUE CAMPUS	ERASMUS DRIVE CRICKET FIELD	47460	110615	2010-01-01
2	SECOND AVENUE CAMPUS	ERASMUS DRIVE CRICKET FIELD	125281	115917	2010-01-01
3	BIRD STREET CAMPUS	THE LEADERSHIP ACADEMY	69658	125497	2010-01-01
4	BIRD STREET CAMPUS	THE LEADERSHIP ACADEMY	65910	125519	2010-01-01
5	SECOND AVENUE CAMPUS	ERASMUS DRIVE CRICKET FIELD	89288	125750	2010-01-01
6	BIRD STREET CAMPUS	THE LEADERSHIP ACADEMY	116419	126348	2010-01-01
7	BIRD STREET CAMPUS	GRADUATE SCHOOL OF BUSINESS	62686.6357056695	146497	2010-01-01
8	BIRD STREET CAMPUS	SUPPORT SERVICES	530.343787696019	146497	2010-01-01
9	BIRD STREET CAMPUS	UNALLOCATED	24714.0205066345	146497	2010-01-01
10	BIRD STREET CAMPUS	GRADUATE SCHOOL OF BUSINESS	30637.8962605549	146892	2010-01-01

Figure 5-10: Electricity usage data contained in the environmental DW

5.6.2 Sustainable BI Strategic Capabilities

Strategic sustainability information management involves using the capabilities provided by the analytical, monitoring and presentation layers. Sustainable BI provides all capabilities that were identified in the requirements for a BI solution to support strategic sustainability information management. Performance dashboards are provided to enable users to visualise all the sustainability information provided as per the identified requirements (R1, R3, R7, and R8) (Section 5.6.2.1). OLAP capabilities are provided on the dashboards, which enable users to drill-down and drill-up into the different aggregations of information (R4) (Section 5.6.2.2). Forecasting capabilities are also provided to enable management to determine if it's on track to meet long-term sustainability goals (R5) (Section 5.6.2.3). Reporting capabilities are provided to enable users to create reports that can be shared amongst both internal and external stakeholders (R6) (Section 5.6.2.4). Filtering capabilities are also provided to enable users to select only the information that they require (R2) (Section 5.6.2.5).

5.6.2.1 Performance Dashboards

Performance dashboards can provide strategic management with a tool to monitor strategic sustainability information and therefore a platform is provided to more effectively manage sustainability. The performance dashboards provided by Sustainable BI, provide users with the capabilities to monitor key metrics and KPIs (R1, R3). Information is aggregated into a single view per subject area, for example: electricity usage, water usage, success rates, enrolments and finances. Sustainable BI provides performance dashboards that cover multiple aspects of sustainability (R7, R8) (Figure 5-11 and Figure 5-12).

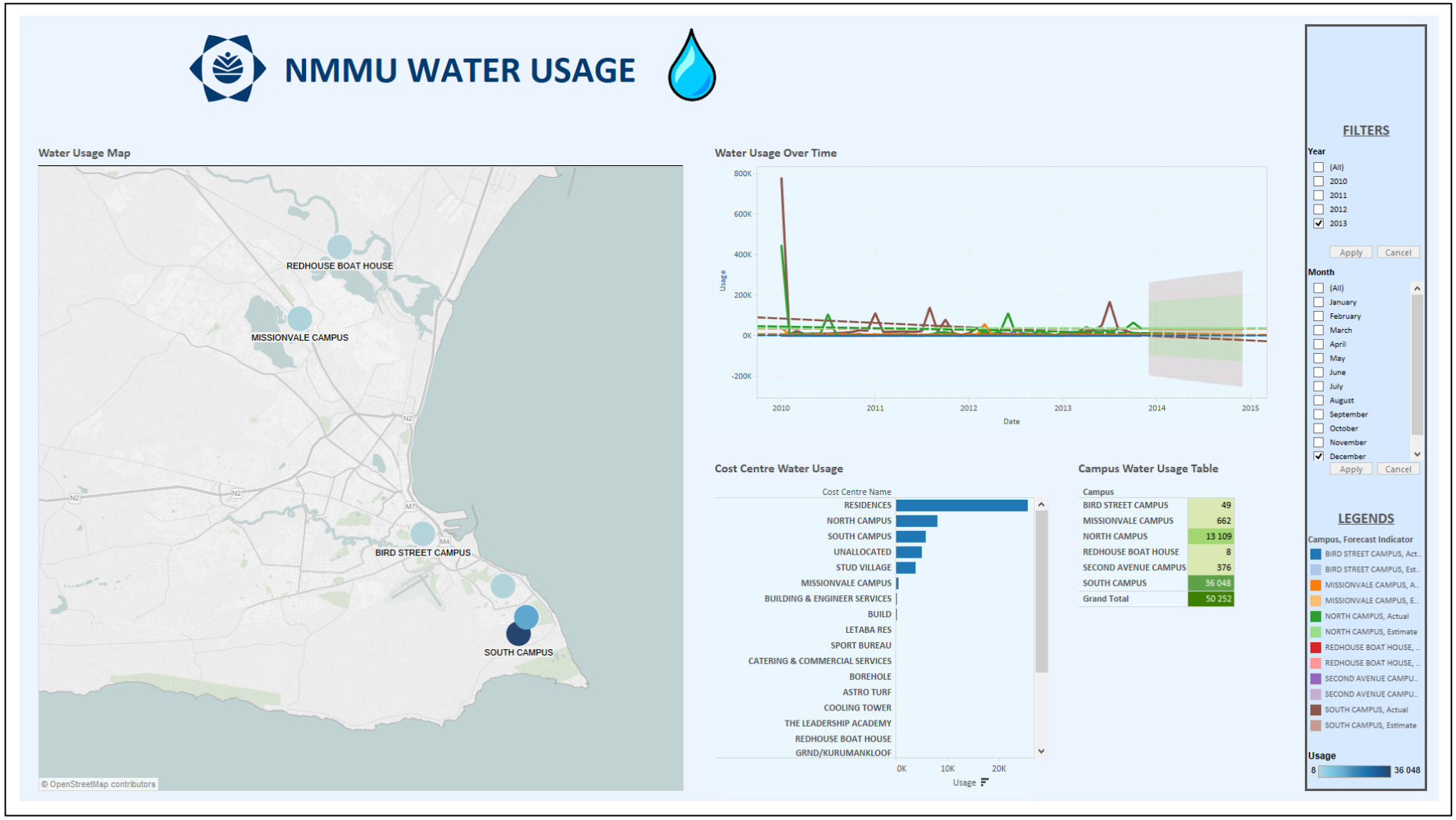

Figure 5-11: Environmental dashboard in Sustainable BI

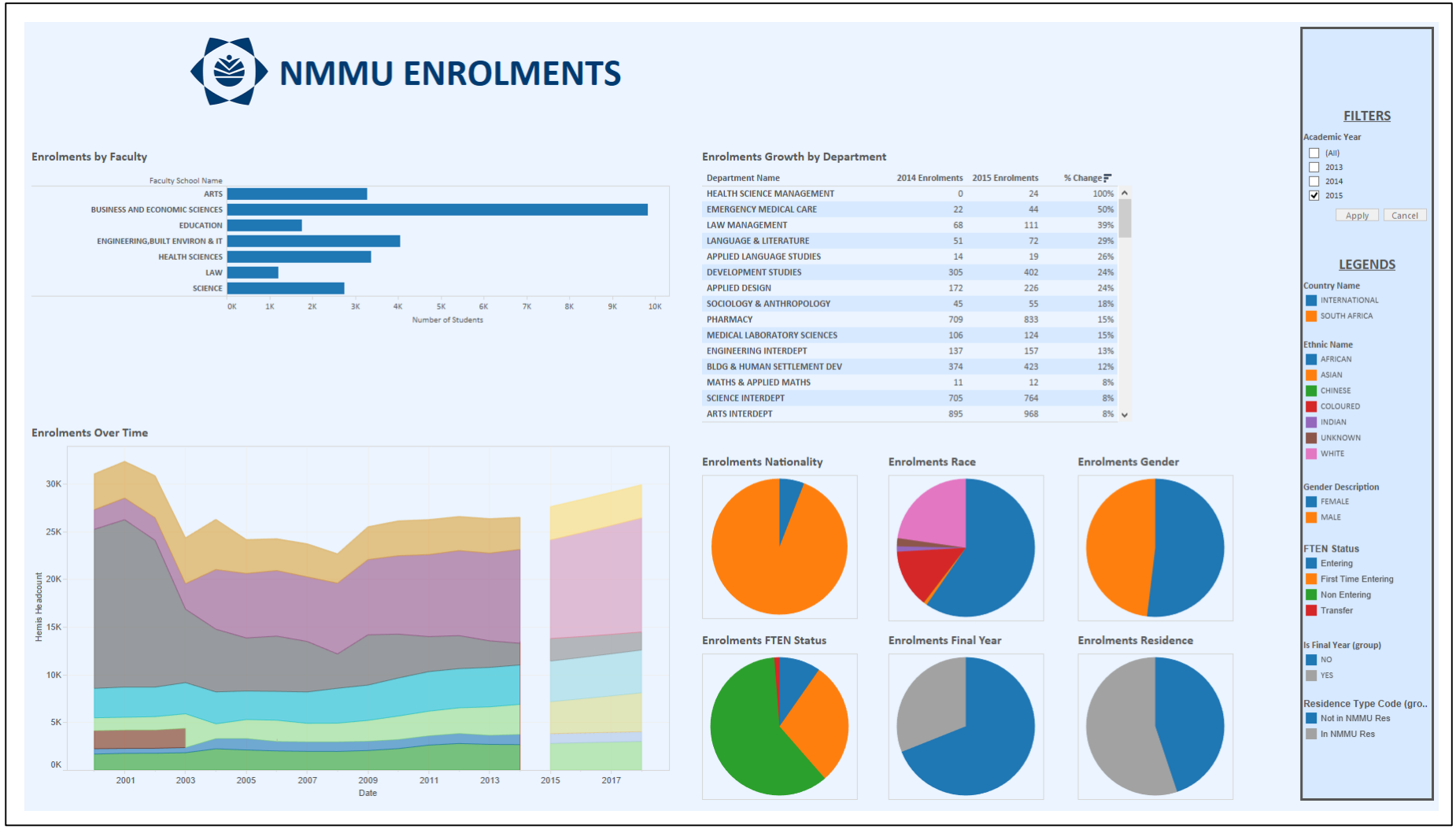

Figure 5-12: Educational dashboard in Sustainable BI

5.6.2.2 OLAP

One of the OLAP capabilities provided by Sustainable BI is the drilling-down and drilling-up of information (R4). Drilling-down and drilling-up enable users to view data from different levels of aggregation. Viewing data from a high level of aggregation can enable management to determine if there is a problem with operations that requires action. Viewing more detailed data with low aggregation can help management determine what the root cause of the problem is. Drill-downs can be set-up by creating hierarchies in the information (Figure 5-13).

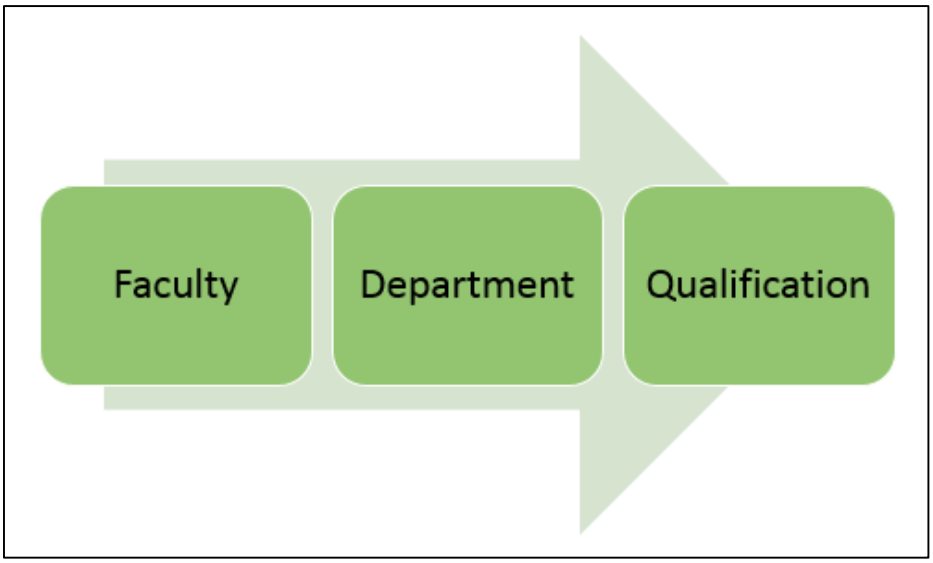

Figure 5-13: Hierarchy of information for drilling down (Author's own construct)

Figure 5-14 provides an example of applications per faculty at NMMU. For example, three important dimensions regarding student enrolments, in the educational category of sustainability, are faculty, department and qualification. If management believe that there is an issue with the number of applications in the law faculty, they can drill down into the law faculty to view applications at the department level and at the qualification level.

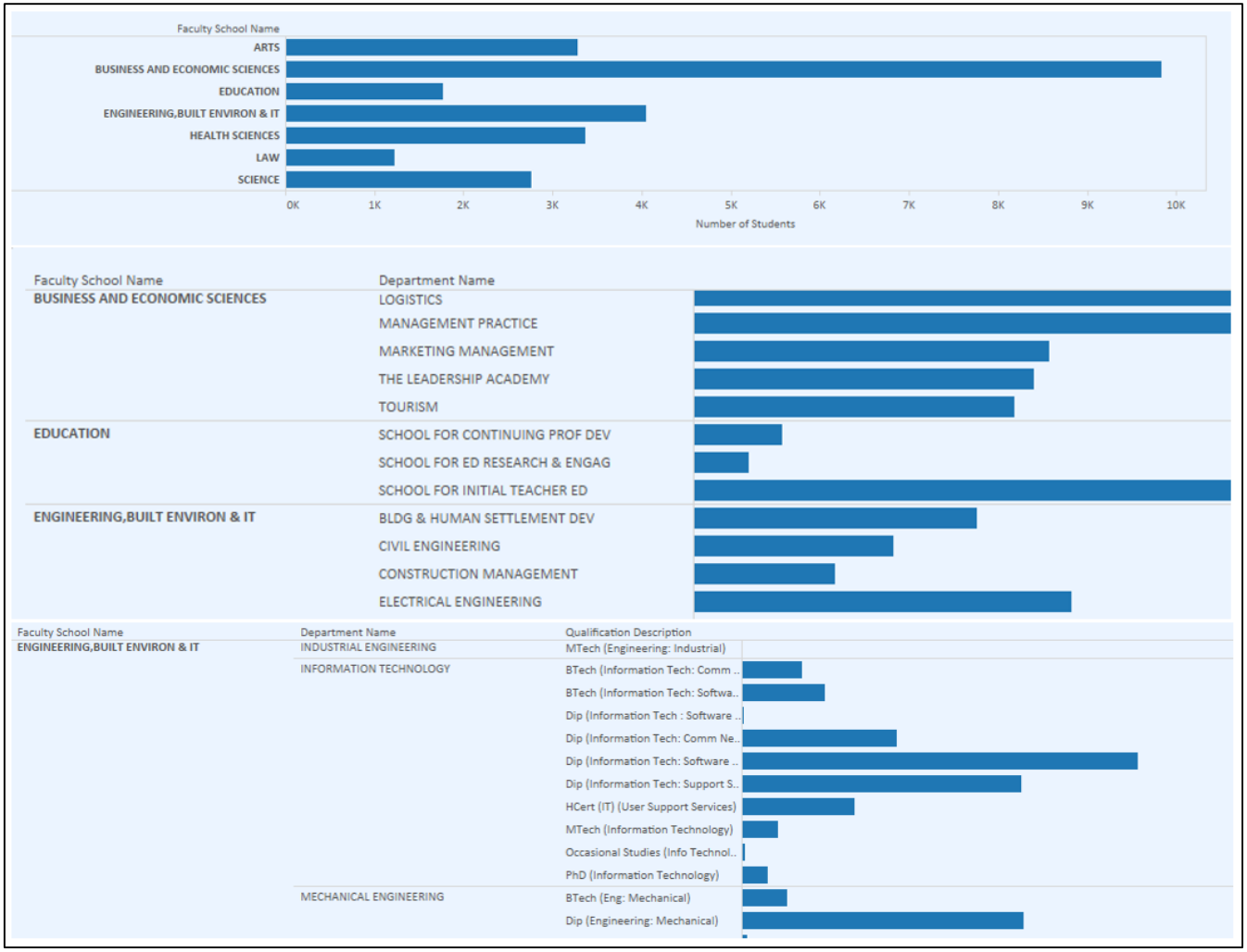

Figure 5-14: Drill-down in Sustainable BI

5.6.2.3 Forecasting

The performance dashboards provided by Sustainable BI also provide analysis capabilities to enable the users to gain greater insights into the information. One of the components missing from NMMU's existing BI solution, InfoPoint, is predictive capabilities. Sustainable BI provides forecasting capabilities which provides predictions based on historical information (R5). An example of forecasting provided by Sustainable BI is the prediction of electricity usage and enrolments at the university (Figure 5-15). The forecasting capabilities provided by Sustainable BI, can enable strategic management to determine if they are on track to meet strategic sustainability goals identified in the long-term strategic plan, Vision 2020.

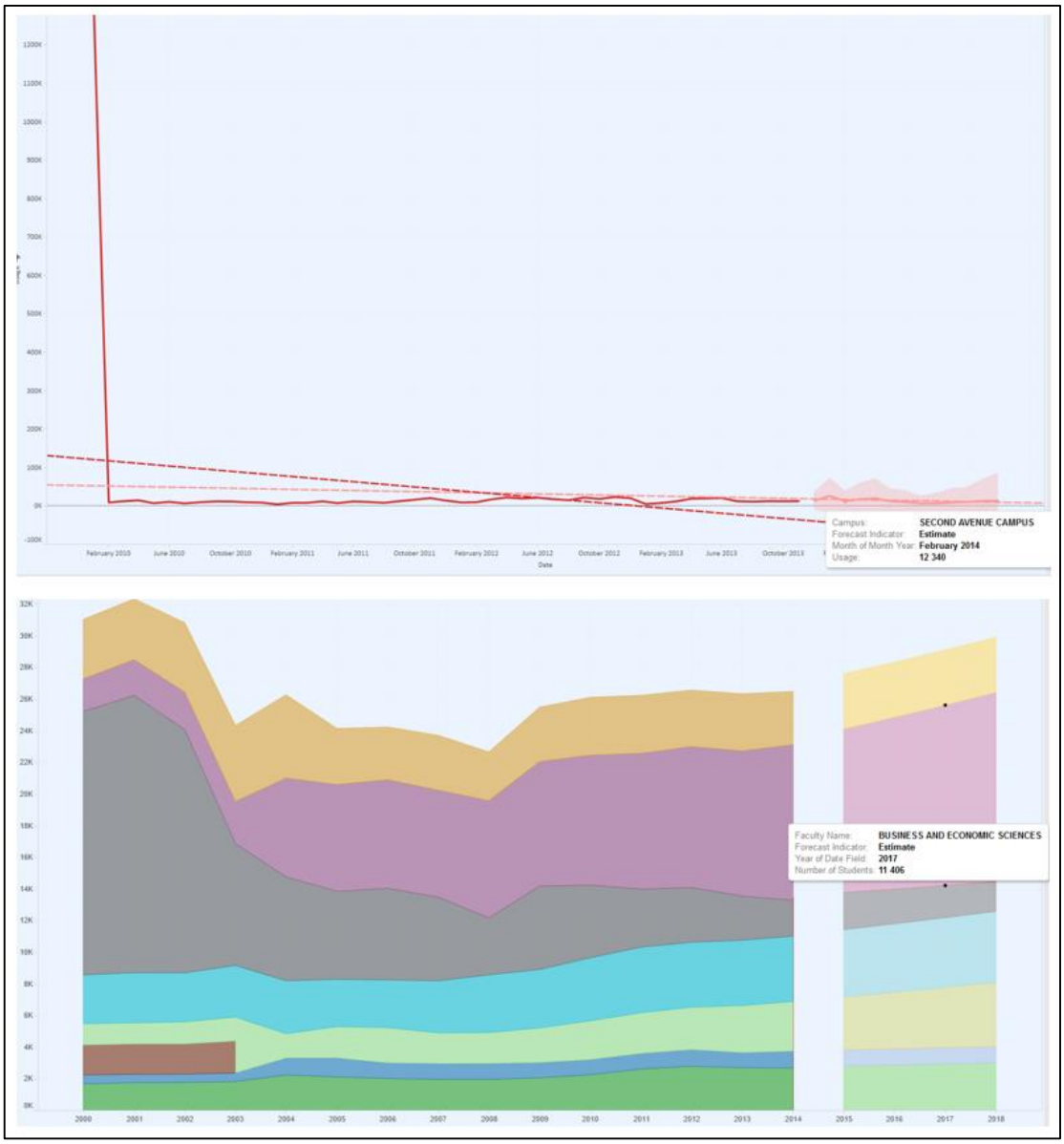

Figure 5-15: Forecasting in Sustainable BI

The analytical capabilities, such as forecasting, are limited in Tableau. Therefore a more advanced statistical programme, R, was used. R is a statistical computing programme that enables the development of advanced statistical models. Tableau comes standard with R integration capabilities and therefore R was used to provide better forecasting models (Figure 5-16). A forecasting model was developed using R, and imported into Sustainable BI.

```
Console ~/
> ####load data
> enrolments <- read.table("C:/Users/s210081988/Desktop/enrolments.csv", quote="\"", comment.char="")
> View(enrolments)
>
> ####plot
> plot.ts(enrolments)
>
> #### predict
> enrolments.mean <- HoltWinters(enrolments, alpha = 0.2, beta = FALSE, gamma = FALSE)
> enrolments.pred <- predict(enrolments.mean, n.ahead = 6, prediction.interval = TRUE)
> plot.ts(enrolments, xlim=c(0, 30))
> lines(enrolments.mean$fitted[,1], col="green" )
> lines(enrolments.pred[,1], col="blue")
> lines(enrolments.pred[,2], col = "red")
>
```

Figure 5-16: Forecasting model created in R

A summary of the enrolments forecasting models is provided in Figure 5-17. The summary outlines which measures were used, the time period of the data the forecast is based on as well as the time period for which the forecast should be provided. A brief description of the model for each faculty is also provided.

Options Used to Create Forecasts

Time series: Year of Date
Measures: Sum of Hemis Headcount
Forecast forward: 6 years (2015 – 2020)
Forecast based on: 2000 – 2014
Ignore last: 1 year (2015)
Seasonal pattern: None (Search for a seasonal pattern in yearly data is not supported)

Sum of Hemis Headcount

Color Faculty	Initial 2015	Change From Initial 2015 – 2020	Seasonal Effect High	 Low	Contribution Trend	 Season
SCIENCE	1 535 ± 10.9%	11.9%	None		100.0%	0.0%
LAW	497 ± 42.0%	0.0%	None		0.0%	0.0%
HEALTH SCIENCES	903 ± 12.1%	23.4%	None		100.0%	0.0%
ENGINEERING,BUILT ENVIRON & IT	3 159 ± 8.3%	7.1%	None		100.0%	0.0%
EDUCATION	613 ± 55.7%	-33.3%	None		100.0%	0.0%
BUSINESS AND ECONOMIC SCIENCES	4 618 ± 14.5%	24.6%	None		100.0%	0.0%
ARTS	1 362 ± 30.3%	0.0%	None		0.0%	0.0%

Figure 5-17: Summary of forecasting models

5.6.2.4 Reporting

The BI solution provides users with the capabilities to create reports in a CSV format, which can then be shared with other users (R6). Users can select the information they want from a given dashboard, and publish it to a CSV file. If the user requires the report to be modified, he/she can do so using spreadsheet software such as Microsoft Excel. The CSV reports can be used to provide more detailed information. These reports also provided users with a simple mechanism of sharing information with the relevant stakeholders. The example provided in Figure 5-18 illustrates an example of a CSV report about international graduates at NMMU. This is a detailed report displaying information for each individual student.

	A	B	C	D	E	F	G	H	I
1	**Report:**	**NMMU International Graduates**							
2	**Years:**	**2013-2015**							
3									
4	**Award Year**	**Student Number**	**Student Full Name**	**Qualification Description**	**Qualification Type Description**	**Department Name**	**Faculty School Name**	**Ethnic Name**	**Country Name**
5	2012	207029076	[redacted]	PG Dip (Built Environment)	POST-GRADUATE DIPLOMA OR CERT.	CONSTRUCTION MANAGEMENT	ENGINEERING,BUILT ENVIRON & IT	AFRICAN	SOUTH AFRICA
6	2013	207064646	[redacted]	MTech (Nature Conservation)	MAGISTER TECHNOLOGY DEGREE	NATURAL RESOUR MAN GEORGE	GEORGE CAMPUS	WHITE	SOUTH AFRICA
7	2013	210054328	[redacted]	MSc (Botany)	MASTER'S DEGREE	BOTANY	SCIENCE	WHITE	SOUTH AFRICA
8	2013	8611408	[redacted]	MTech (Forestry)	MAGISTER TECHNOLOGY DEGREE	NATURAL RESOUR MAN GEORGE	GEORGE CAMPUS	WHITE	SOUTH AFRICA
9	2013	207050046	[redacted]	MTech (Forestry)	MAGISTER TECHNOLOGY DEGREE	NATURAL RESOUR MAN GEORGE	GEORGE CAMPUS	AFRICAN	SOUTH AFRICA
10	2013	204042437	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
11	2013	212448307	[redacted]	PG Cert (Education : FET)	POST-GRADUATE DIPLOMA OR CERT.	SCHOOL FOR INITIAL TEACHER ED	EDUCATION	AFRICAN	SOUTH AFRICA
12	2013	210224517	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	COLOURED	SOUTH AFRICA
13	2013	198348980	[redacted]	PhD (Construction Management)	DOCTORAL DEGREE	CONSTRUCTION MANAGEMENT	ENGINEERING,BUILT ENVIRON & IT	WHITE	SOUTH AFRICA
14	2013	210117834	[redacted]	PhD (Information Technology)	DOCTORAL DEGREE	INFORMATION TECHNOLOGY	ENGINEERING,BUILT ENVIRON & IT	WHITE	SOUTH AFRICA
15	2013	206547350	[redacted]	PhD (Education)	DOCTORAL DEGREE	SCHOOL FOR ED RESEARCH & ENGAG	EDUCATION	AFRICAN	SOUTH AFRICA
16	2013	205063021	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
17	2013	203079140	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
18	2013	206581770	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
19	2013	211250007	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
20	2013	211255289	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
21	2013	211245186	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
22	2013	206550820	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
23	2013	206550460	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
24	2013	211227498	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
25	2013	211246956	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
26	2013	211220647	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
27	2013	212439804	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
28	2013	205059627	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
29	2013	206462190	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
30	2013	202369439	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
31	2013	206661970	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
32	2013	211262064	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
33	2013	206551030	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
34	2013	208092567	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
35	2013	207071994	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
36	2013	209085316	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
37	2013	196386470	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
38	2013	204028949	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
39	2013	209030902	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
40	2013	209083420	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
41	2013	206663850	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
42	2013	210221283	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
43	2013	209081527	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
44	2013	211249599	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
45	2013	209030738	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA
46	2013	201354853	[redacted]	BEdHons	HONOURS DEGREE	SCHOOL FOR CONTINUING PROF DEV	EDUCATION	AFRICAN	SOUTH AFRICA

Figure 5-18: Detailed CSV report created using Sustainable BI

Creating a CSV report requires extracting detailed data from one of the data warehouses used in the design and development of Sustainable BI. The example, provided in Figure 5-19, shows an example of the SQL code that is required to extract the data required to generate the report. In the example provided, a report is created for enrolments at NMMU. The data is extracted from the Enrolments fact table, along with several other dimension tables.

```
SELECT    dbo.Dim_Qualification.Qualification_Description, dbo.Dim_Qualification_Type.Qualification_Type_Description,
          dbo.Dim_Department.Department_Name, dbo.Dim_Marital_Status.Marital_Status_Description,
          dbo.Dim_Country.Country_Name, dbo.Dim_Gender.Gender_Description, dbo.Dim_Language.Language_Description,
          dbo.Dim_Ethnic.Ethnic_Name, dbo.Dim_Formal_Indicator.Formal_Indicator_Desc,
          dbo.Dim_Subject_Offering.Subject_Offering_Description, dbo.Dim_FTEN_Status.FTEN_Status,
          dbo.Dim_Faculty_School.Faculty_School_Name, dbo.dbo_Fact_Student_Enrollment.Academic_Year,
          dbo.dbo_Fact_Student_Enrollment.Preparatory_Time, dbo.dbo_Fact_Student_Enrollment.Experiemental_Time,
          dbo.dbo_Fact_Student_Enrollment.Is_Final_Year,
          dbo.dbo_Fact_Student_Enrollment.Exam_Block_Code, dbo.dbo_Fact_Student_Enrollment.Minimum_Research_Time,
          dbo.dbo_Fact_Student_Enrollment.Qualification_Number,
          dbo.dbo_Fact_Student_Enrollment.Residence_Type_Code, dbo.dbo_Fact_Student_Enrollment.Is_Loan_Required,
          dbo.dbo_Fact_Student_Enrollment.Socio_Economic_Category,
          dbo.dbo_Fact_Student_Enrollment.Secondary_School, dbo.dbo_Fact_Student_Enrollment.Matric_Type,
          dbo.dbo_Fact_Student_Enrollment.Matric_Date, dbo.Dim_Study_Period.Study_Period_Description,
          dbo.Dim_Student.Student_Type_Description, dbo.Dim_Student.Student_Surname, dbo.Dim_Student.Student_First_Name,
          dbo.Dim_Student.Student_Initials, dbo.Dim_Student.Student_Title,
          dbo.Dim_Student.Student_Full_Name, dbo.Dim_Student.Student_Number,
FROM      dbo.dbo_Fact_Student_Enrollment INNER JOIN
          dbo.Dim_Qualification ON dbo.dbo_Fact_Student_Enrollment.Qualification_SK = dbo.Dim_Qualification.Qualification_SK INNER JOIN
          dbo.Dim_Qualification_Type ON dbo.dbo_Fact_Student_Enrollment.Qualification_Type_SK = dbo.Dim_Qualification_Type.Qualification_Type_SK INNER JOIN
          dbo.Dim_Department ON dbo.dbo_Fact_Student_Enrollment.Department_SK = dbo.Dim_Department.Department_SK INNER JOIN
          dbo.Dim_Faculty_School ON dbo.dbo_Fact_Student_Enrollment.Faculty_School_SK = dbo.Dim_Faculty_School.Faculty_School_SK INNER JOIN
          dbo.Dim_Academic_Block ON dbo.dbo_Fact_Student_Enrollment.Academic_Block_SK = dbo.Dim_Academic_Block.Academic_Block_SK INNER JOIN
          dbo.Dim_Study_Period ON dbo.dbo_Fact_Student_Enrollment.Study_Period_SK = dbo.Dim_Study_Period.Study_Period_SK INNER JOIN
          dbo.Dim_Ethnic ON dbo.dbo_Fact_Student_Enrollment.Ethnic_SK = dbo.Dim_Ethnic.Ethnic_Sk INNER JOIN
          dbo.Dim_Gender ON dbo.dbo_Fact_Student_Enrollment.Gender_SK = dbo.Dim_Gender.Gender_Sk INNER JOIN
          dbo.Dim_Country ON dbo.dbo_Fact_Student_Enrollment.Country_SK = dbo.Dim_Country.Country_Sk INNER JOIN
          dbo.Dim_Marital_Status ON dbo.dbo_Fact_Student_Enrollment.Marital_Status_SK = dbo.Dim_Marital_Status.Marital_Status_Sk INNER JOIN
          dbo.Dim_Language ON dbo.dbo_Fact_Student_Enrollment.Language_SK = dbo.Dim_Language.Language_Sk INNER JOIN
          dbo.Dim_Subject_Offering ON dbo.dbo_Fact_Student_Enrollment.Subject_Offering_SK = dbo.Dim_Subject_Offering.Subject_Offering_SK INNER JOIN
          dbo.Dim_FTEN_Status ON dbo.dbo_Fact_Student_Enrollment.FTEN_Status_Sk = dbo.Dim_FTEN_Status.FTEN_Status_SK INNER JOIN
          dbo.Dim_Formal_Indicator ON dbo.dbo_Fact_Student_Enrollment.Formal_Indicator_Sk = dbo.Dim_Formal_Indicator.Formal_Indictor_SK INNER JOIN
          dbo.Dim_Student ON dbo.dbo_Fact_Student_Enrollment.Student_SK = dbo.Dim_Student.Student_SK INNER JOIN
          dbo.Dim_PostGrad_UnderGrad ON dbo.dbo_Fact_Student_Enrollment.Graduate_Level_Sk = dbo.Dim_PostGrad_UnderGrad.Post_Graduate_SK
```

Figure 5-19: Creating a CSV report using SQL

An alternative reporting capability provided by Sustainable BI is the pdf reporting capability. The pdf reporting capability enables users to create a static screenshot of any of the dashboards in Sustainable BI (Figure 5-20). The pdf reporting capability enables users to share more graphical reports with the relevant stakeholders.

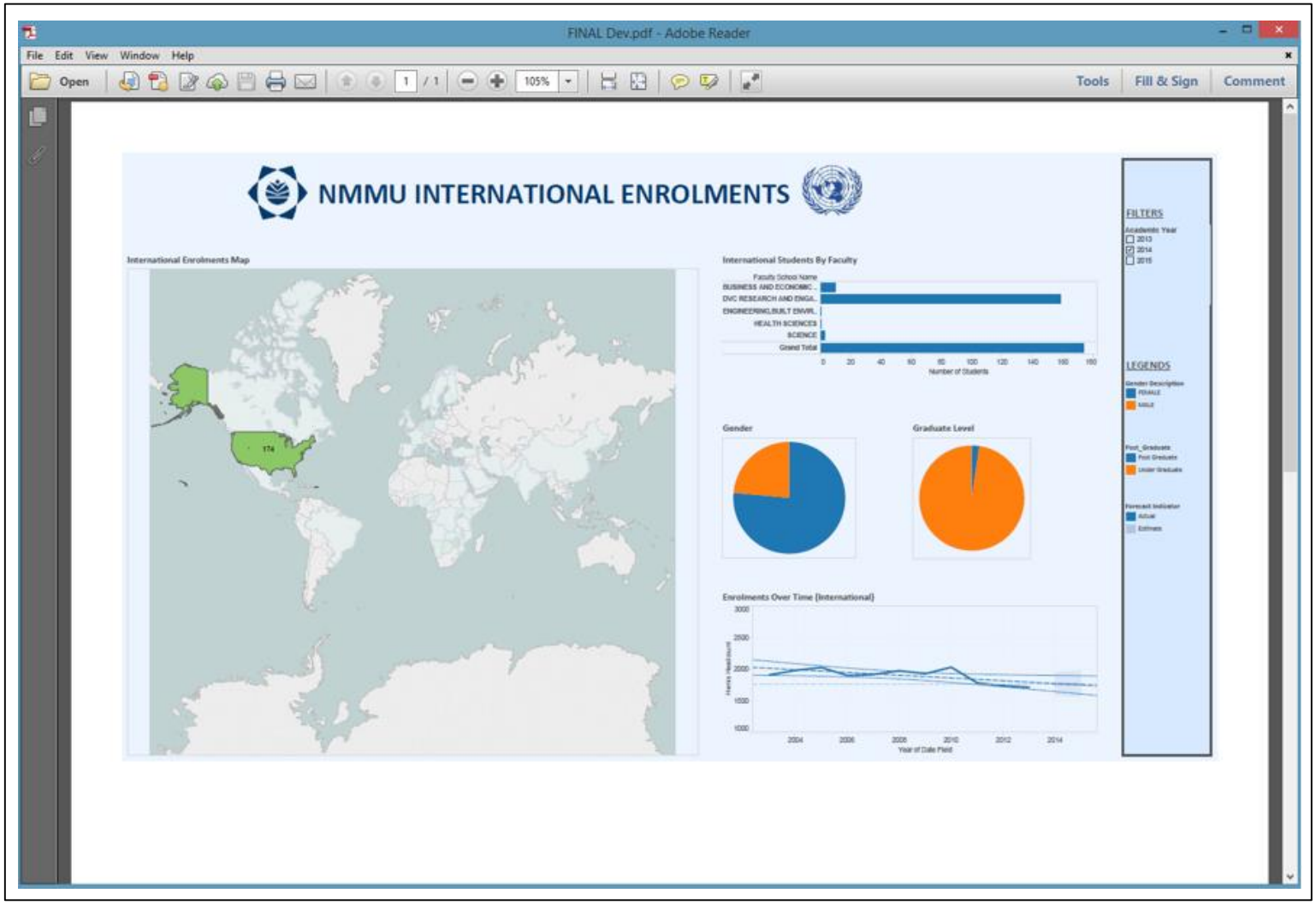

Figure 5-20: Sustainable BI pdf report

5.6.2.5 Filtering

Often users will require capabilities to customise information based on their specific needs. Filtering provides users with the capabilities to select specific information and exclude information that is not relevant. Sustainable BI provides filtering capabilities through two distinct methods (Figure 5-21). The first method for filtering is the filtering toolbar, which provides radio buttons and checkboxes from which users can select the required information. The second method for filtering is filtering through the dashboard components. Sustainable BI provides dynamic dashboards from which users can select components of a graph, which filters the information on the rest of the dashboard according to the selection (R2).

Figure 5-21: Filtering information in Sustainable BI

5.6.3 Dashboard Development Process

Literature revealed a number of steps that should take place in the design and developments of dashboards (Section 4.4). The design and development process should involve six separate steps (Caraiani and Dumitrana, 2005):

1. Set the objectives;
2. Define the list of tasks, competencies and responsibilities;
3. Set the indicators;
4. Collect information based on the identified indicators;
5. Develop the dashboard; and
6. Evaluate the dashboard.

The first step in dashboard-development is to set the objectives of the institution. An example of an objective at NMMU, is to *"Establish a distinctive academic brand and educational philosophy at NMMU that promotes critical scholarship and develops well-rounded and responsible graduates capable of success as citizens in the global knowledge society"* (Nelson Mandela Metropolitan University, 2008, p. 25). The second step involves defining who is responsible for managing the broad objectives outlined by strategic management. At NMMU, the deputy vice-chancellors for research and engagement and teaching and learning will be responsible for the identified objective. The third step is to set the objectives that will help to determine the institution's success in achieving the identified objective. An example of an indicator for the identified objective is the success rate at NMMU. NMMU has set a target success rate of 70%.

The fourth step in the dashboard-development process is to collect the information required to measure the indicators. Information about student success rate will need to be collected, which is available in the NMMU ITS students data cube. The fifth step of the development process is to develop the dashboard based on the previous four steps. A snippet from the dashboard is shown in Figure 5-22, where the success rate indicator is measured by using a bar graph. All

faculties below the target success rate are highlighted in orange so that management can see instantly which faculties need attention in order to achieve the target success rate.

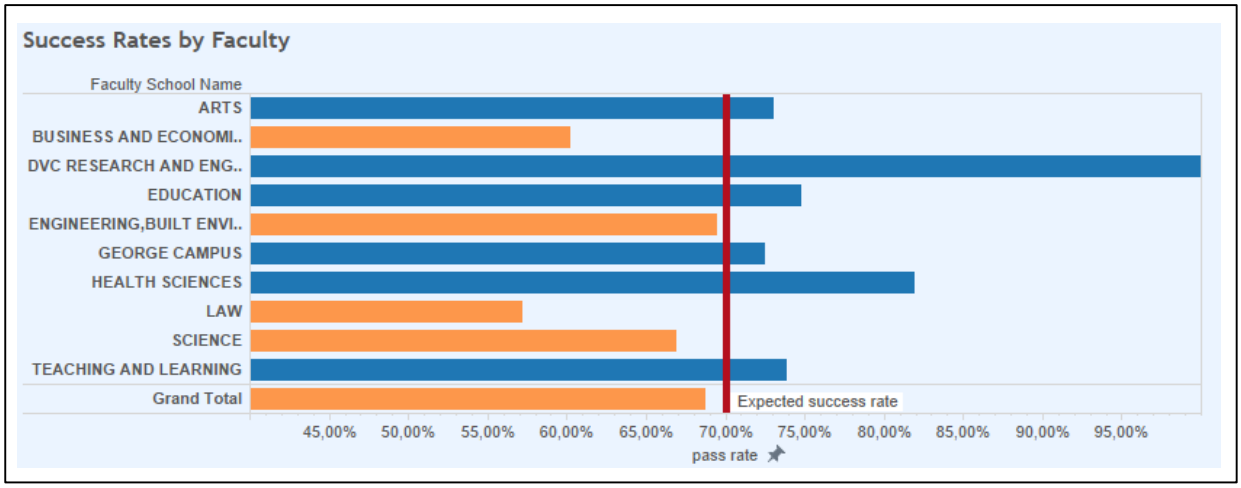

Figure 5-22: Measuring the success rate indicator using Sustainable BI

Determining if the current target success rate is being met requires a comparison of the current success rate and the target success rate. A code snipped is provided, showing sample code used in the development of Sustainable BI (Figure 5-23).

```
Set [Target Success Rate] = 0.7

IF [Success Rate] < [Target Success Rate]
    THEN 'Below Target'
    ELSE 'Above Target'

END
```

Figure 5-23: Code snippet for determining if success rate is above or below target

The final step in the dashboard-development process is to evaluate the dashboard. Evaluation of the dashboard will assist in determining if the dashboard provides management with all the required information, and if the dashboard assists in more effectively managing each of the outlined objectives. The six-step development process was followed throughout the development of Sustainable BI.

5.6.4 Application of Design Guidelines to Sustainable BI

A number of design considerations and common pitfalls for dashboard development were identified (Section 5.4) and considered in the design and development of Sustainable BI, with focus being given to avoiding the common pitfalls with dashboard development. The common pitfalls that were accounted for relate to (Few, 2006b):

- the level of detail of information (Section 5.6.4.1.1);
- using the appropriate media (types of graphs) to display information (Section 5.6.4.1.2);
- arranging information in a logical order (Section 5.6.4.1.3);
- the correct use of colour (Section 5.6.4.1.4);
- highlighting important information (Section 5.6.4.1.5); and
- designing an appealing visual display.

5.6.4.1.1 Level of Detail of Information

Information should be displayed to users with a suitable level of detail (Figure 3-6 and Table 3-8). The focus of Sustainable BI is managing sustainability at a strategic level and therefore the information provided should be aggregated and should provide an overview of the sustainability of the entire organisation. The information provided at the strategic level should focus on organisation metrics and be aligned to organisational goals and objectives.

Sustainable BI provides aggregated information on multiple aspects of sustainability, but also provides drill-down capabilities to view information with a lower level of granularity. For example, the Sustainable BI electricity-usage dashboard provides electricity-usage information for each of the NMMU campuses. However drill-down capabilities can be used to enable users to view electricity usage by cost centre by campus.

5.6.4.1.2 Appropriate Media to Display data

One of the biggest mistakes made by BI developers is using the incorrect media to display information (Few, 2006b). Juice Analytics (2009) provides guidelines for selecting the correct media based on the information being displayed (Figure 5-4), and these were used throughout the development of Sustainable BI.

The types of graphs used to display information can be divided into six categories:

- relationships among data points;
- comparing a set of values;
- tracking rises and falls over time;
- seeing the parts of a whole;
- analysing text; and
- seeing the world (Geographic).

Sustainable BI makes use of four of the six categories of graph types (Table 5-8).

Table 5-8: Graph types used by Sustainable BI

Graph Types	Sustainable BI
Relationships among data points	x
Comparing a set of values	✔
Tracking rises and falls over time	✔
Seeing the parts of a whole	✔
Analysing text	x
Seeing the world (Geographic)	✔

Comparing a set of values

There are several media for comparing a set of values such as bar charts, histograms and bubble charts. A number of bar charts are used in Sustainable BI to compare a set of values. An example of one such bar chart is shown in Figure 5-24, in which success rates are compared by faculty.

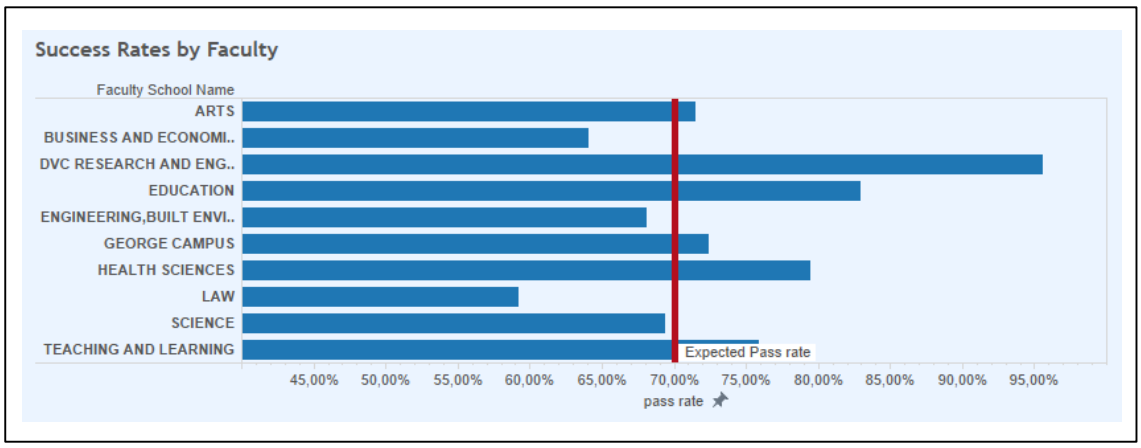

Figure 5-24: Bar chart for comparing a set of values

Tracking rises and falls over time

Tracking information over time can be illustrated through both line graphs and stack graphs. Both of these types of graphs are used in Sustainable BI. An example of a stacked graph is shown in Figure 5-25, in which enrolments an NMMU are shown over time. This example also provides a forecast of predicted enrolments based on current trends.

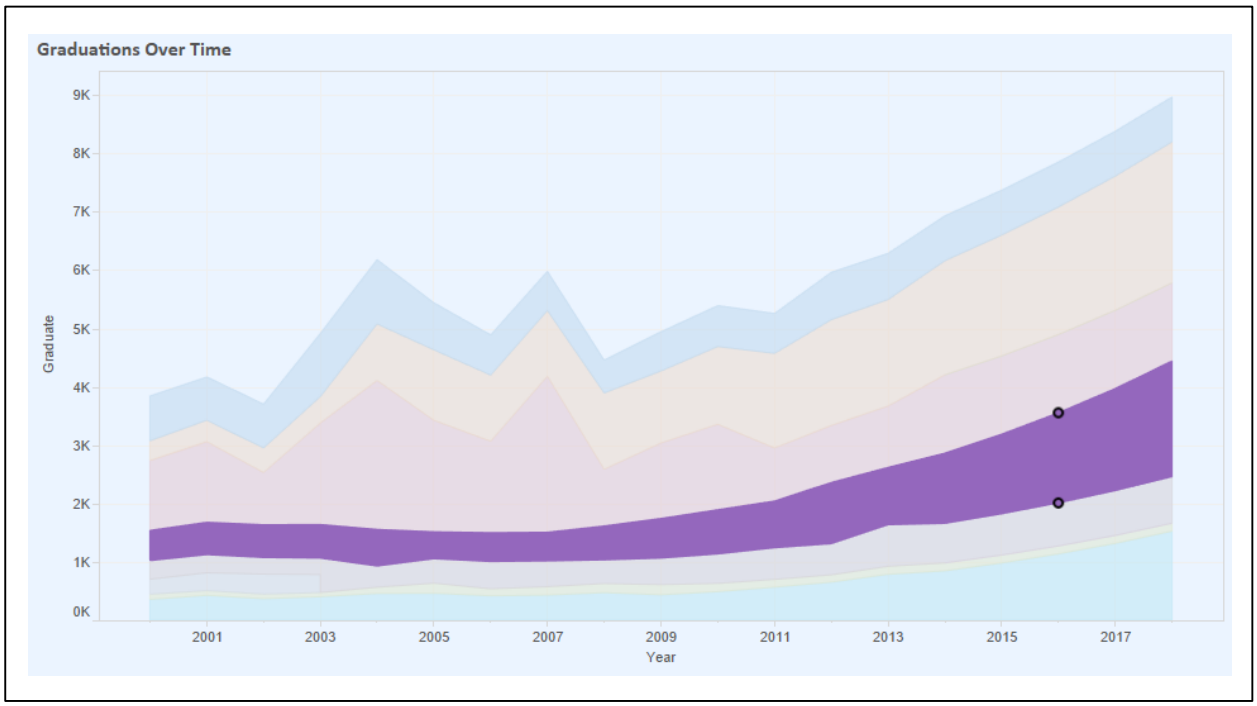

Figure 5-25: Stack graph for tracking rises and falls over time

Seeing the parts of a whole

Both pie charts and treemaps can be used to show data as part of a whole. Sustainable BI makes use of both treemaps and pie charts. An example of a pie chart is shown in Figure 5-26, in which graduates at NMMU are broken down into nationality, race and gender.

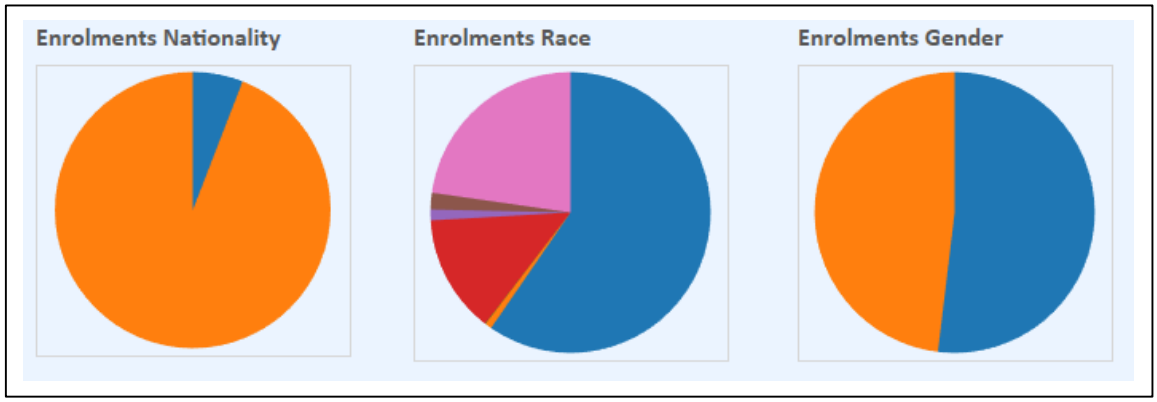

Figure 5-26: Pie charts to see parts of a whole in Sustainable BI

Seeing the world (Geographic)

The final graph type used by Sustainable BI is geographic charts. A lot of information has a graphical component to it, which can be illustrated through the use of a map to enhance the information provided to the user (Figure 5-27).

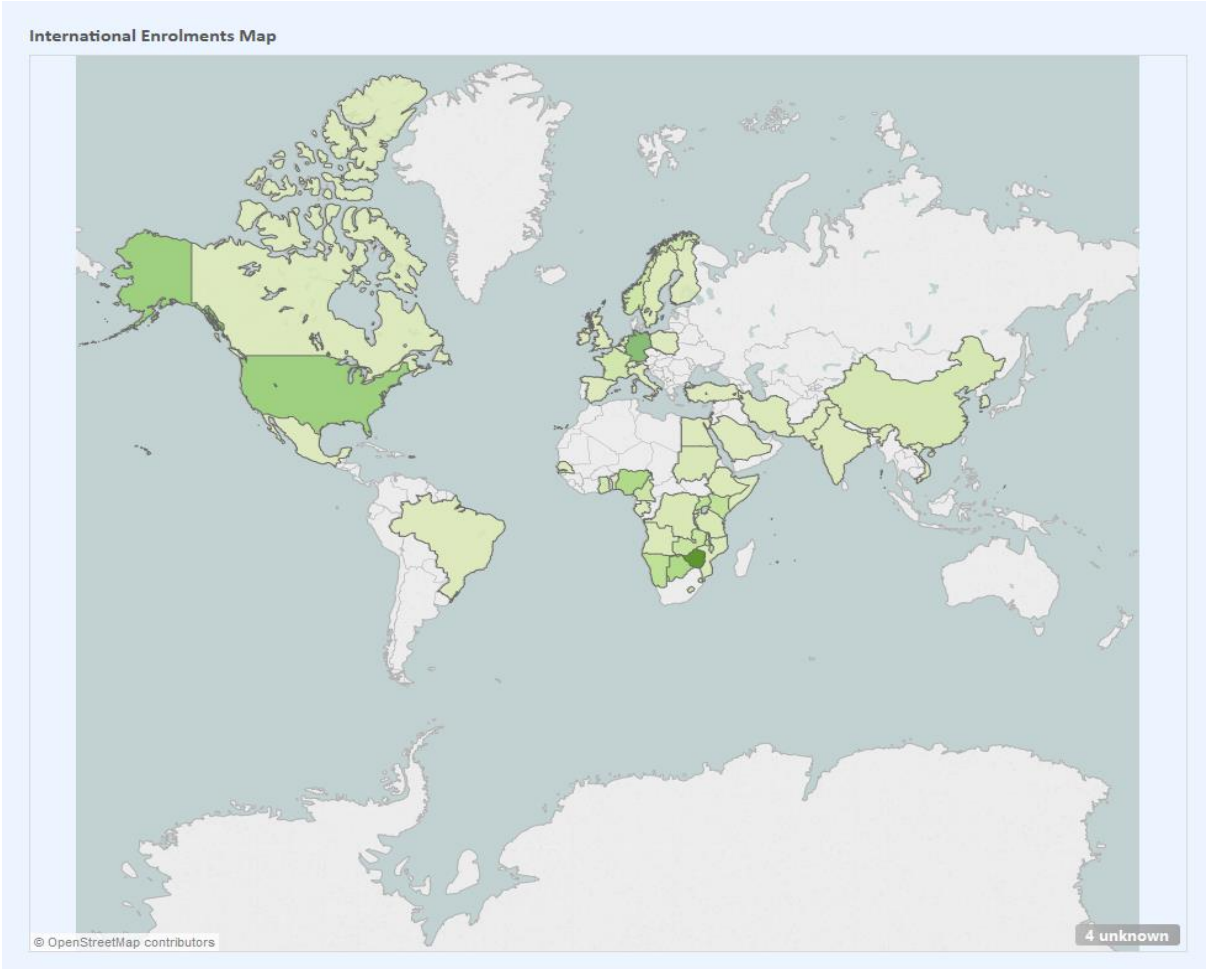

Figure 5-27: Geographic visualisation of information in Sustainable BI

5.6.4.1.3 Arranging Information Logically

Studies have proven that humans read information moving from left to right and top to bottom (Erickson, 2012). The most important information should therefore be placed at the top left of a dashboard. Information placement should also be consistent throughout the entire BI application and related information should be grouped together. Examples of how Sustainable BI arranges information logically can be seen in the example dashboard provided Figure 5-12, where the most important metric, total enrolments, is placed at the top left of the screen.

5.6.4.1.4 Use of Colour

Dashboards often contain a lot of information and therefore the visual content should be kept as simple as possible. Excessive use of colour can cause confusion and distract users from important information (Erickson, 2012). Dashboards should also be consistent with the use of colour. Colour choices should be made based on an understanding of how peoples perceive colour.

5.6.4.1.5 Highlighting Important Information

A performance dashboard should immediately draw the users attention to important information (Few, 2006b). While all information on a dashboard should be important, some information is important, and should be highlighted to draw the user's attention. Sustainable BI provides functionality to highlight important information. One of the educational KPIs identified at NMMU is a success rate of 70%. Figure 5-28 provides an example of a graph in Sustainable BI that illustrates the success rates per faculty at NMMU. By highlighting the faculties with a success rate below 70% in orange, management can easily determine which faculties need greater attention.

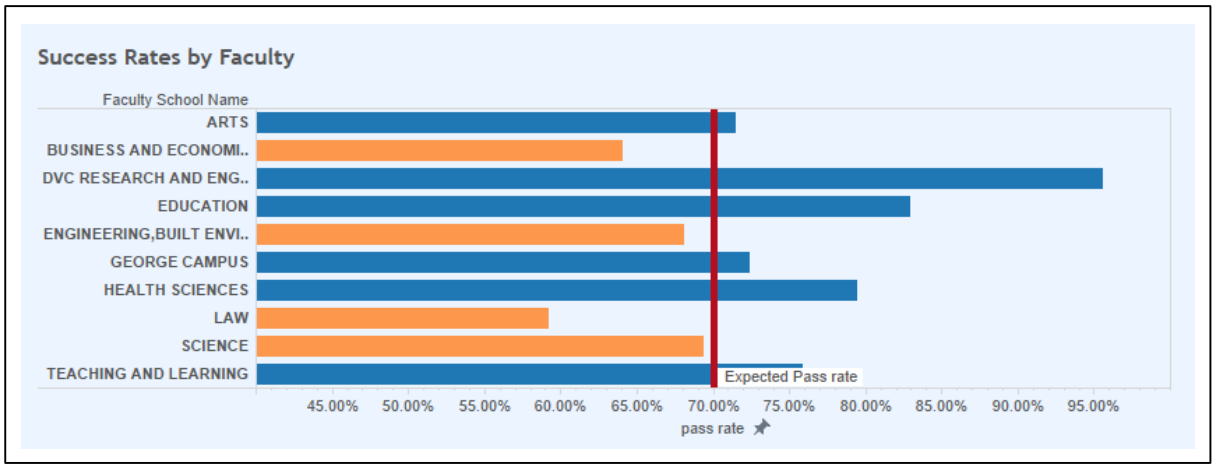

Figure 5-28: Highlighting important information in Sustainable BI

5.7 Fulfilment of Objectives and Requirements

An analysis of the existing BI system at NMMU, InfoPoint, found that its capabilities did not enable it to satisfy all the functional requirements of BI solution to support strategic sustainability information management. InfoPoint does not provide dynamic and interactive

dashboards, it does not provide predictive capabilities, and it does not cover multiple aspects of sustainability.

A new BI solution, Sustainable BI, was developed to provide the capabilities required to satisfy all the functional requirements of a BI solution. All the functional requirements not satisfied by InfoPoint were satisfied by Sustainable BI (Table 5-9). Sustainable BI provides dynamic dashboards that provide easy interaction and enable users to select and filter information as required (Section 5.6.2.1 and Section 5.6.2.5). Forecasting capabilities are provided, which enable users to predict future outcomes based on historical information (Section 5.6.2.3). The dashboard also covers multiple aspects of sustainability as sustainable BI provides information on both the educational and environmental aspects of sustainability.

Table 5-9: InfoPoint vs Sustainable BI satisfaction of functional requirements

Requirement Number	Requirement	Requirement Satisfied by InfoPoint	Requirement Satisfied by Sustainable BI
R1	The BI solution must provide up-to-date sustainability information through reports, dashboards and scorecards.	✔	✔
R2	Dashboards should be dynamic and interactive.	✘	✔
R3	The BI solution should provide information to the users to assist in monitoring KPIs.	✔	✔
R4	The information should be aggregated but allow drill-down capabilities to enable root-cause analysis.	✔	✔
R5	The BI solution should make use of forecasting/predictive capabilities.	✘	✔
R6	The BI solution should enable the sharing of sustainability information.	✔	✔
R7	Information should be gathered from multiple sources.	✔	✔
R8	The BI solution should cover more than one aspect of sustainability.	✘	✔

5.8 Conclusions

The third step in the DSR methodology is the design and development of the artefact, Sustainable BI. Sustainability Management Model was proposed in Chapter 4 (Figure 4-10). The model was validated through interviews to determine the biggest constraints to managing strategic sustainability information at NMMU, the challenges with implementing a BI solution at NMMU, and the factors deemed critical to the success of a BI project at NMMU. The interviews revealed that the biggest constraints to effective strategic sustainability information management are siloed data and information and poor sharing and communication of information. This is a result of the siloed nature of NMMU's BI solution, InfoPoint, which focusses entirely on the educational aspect of sustainability. A systems analysis was conducted on InfoPoint to determine its capabilities and how it aligns with the requirements of a BI solution to effectively manage strategic sustainability information. The extant systems analysis revealed that the existing system did not meet all the requirements as it failed to provide dynamic and interactive dashboards, predictive capabilities, and it only focussed on the educational aspect of sustainability. It is therefore evident that an improved system was required to effectively manage strategic sustainability information.

The requirement of an improved BI solution that satisfied all requirements identified in Chapter 4, led to the development of Sustainable BI. The DSR methodology also requires measures for evaluating the artefact. This chapter identified the evaluation metrics as part of the evaluation plan (Section 5.2). The research question that this chapter answered was:

RO_7: How should a BI solution to support strategic sustainability information management solution be designed and evaluated?

The sustainable BI architecture illustrates how a BI solution to support sustainability information management should be designed (Figure 5-5). The evaluation plan outlines ten heuristics that a BI solution, and in particular performance dashboards, should adhere to (Section 5.2.2.1.1). The metrics upon which the success of a BI solution should be measure against are also identified (Section 5.2.2.2.5). The next chapter outlines the results of the evaluation of the Sustainable BI prototypes. The evaluations consists of a heuristic evaluation as well as a usability evaluation. The usability evaluation provides a platform through which the effectiveness of the Sustainable BI can be measured.

Chapter 6. Evaluation Results (Sustainable BI)

6.1 Introduction

The previous chapter addressed the third phase of the DSR methodology, the design and development of the artefact, Sustainable BI. The chapter also provided a plan for the evaluation of both the proposed sustainability model for HEIs and Sustainable BI, and the results of the sustainability model evaluation. The evaluation of Sustainable BI consists of a heuristic evaluation, as well as a full usability evaluation.

This chapter addresses two phases of the DSR process, namely the demonstration and the evaluation of the artefact, Sustainable BI (Figure 6-1). The evaluation of Sustainable BI, will assist in determining the usability of the software and determine to what extent the BI can assist in effectively managing strategic sustainability information. The usability metrics identified in the previous chapter that will be used are: visibility, flexibility, learnability, error control and help, effectiveness and efficiency (Section 5.2.2.2.5).

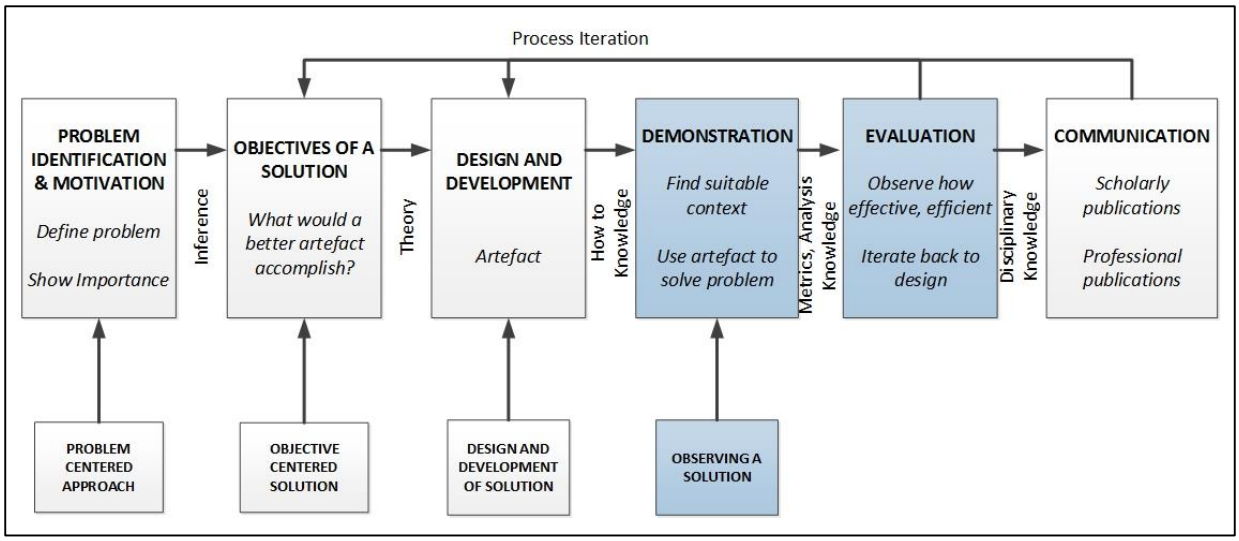

Figure 6-1: Demonstration and evaluation stages of DSR (Peffers et al., 2006)

The usability study will assist in answering the research question that research question that this chapter seeks to answer, namely: RQ_8*: To what extent can the implemented BI solution support effective and efficient strategic sustainability information management in HEIs?*

The chapter provides the results of the heuristic evaluation for Prototype One of Sustainable BI (Section 6.2). Upon completion of the heuristic evaluation, modifications to Prototype One of Sustainable BI were made, which resulted in the development of Prototype Two of Sustainable BI (Section 6.3). Once the modifications were made to Sustainable BI, a full usability evaluation will be conducted to determine if Sustainable BI meets all the identified requirements and objectives (Section 6.4). The recommended changes identified in the usability evaluation will be made to Sustainable BI, which will lead to the development of Prototype Three of Sustainable BI, the final prototype in this study (Section 6.5). Thereafter the objectives and requirements of Sustainable BI are revisited in order to determine whether these requirements and objectives were met (Section 6.6). Conclusions from the chapter are then drawn (Section 6.7). A full outline of the chapter is provided in Figure 6-2.

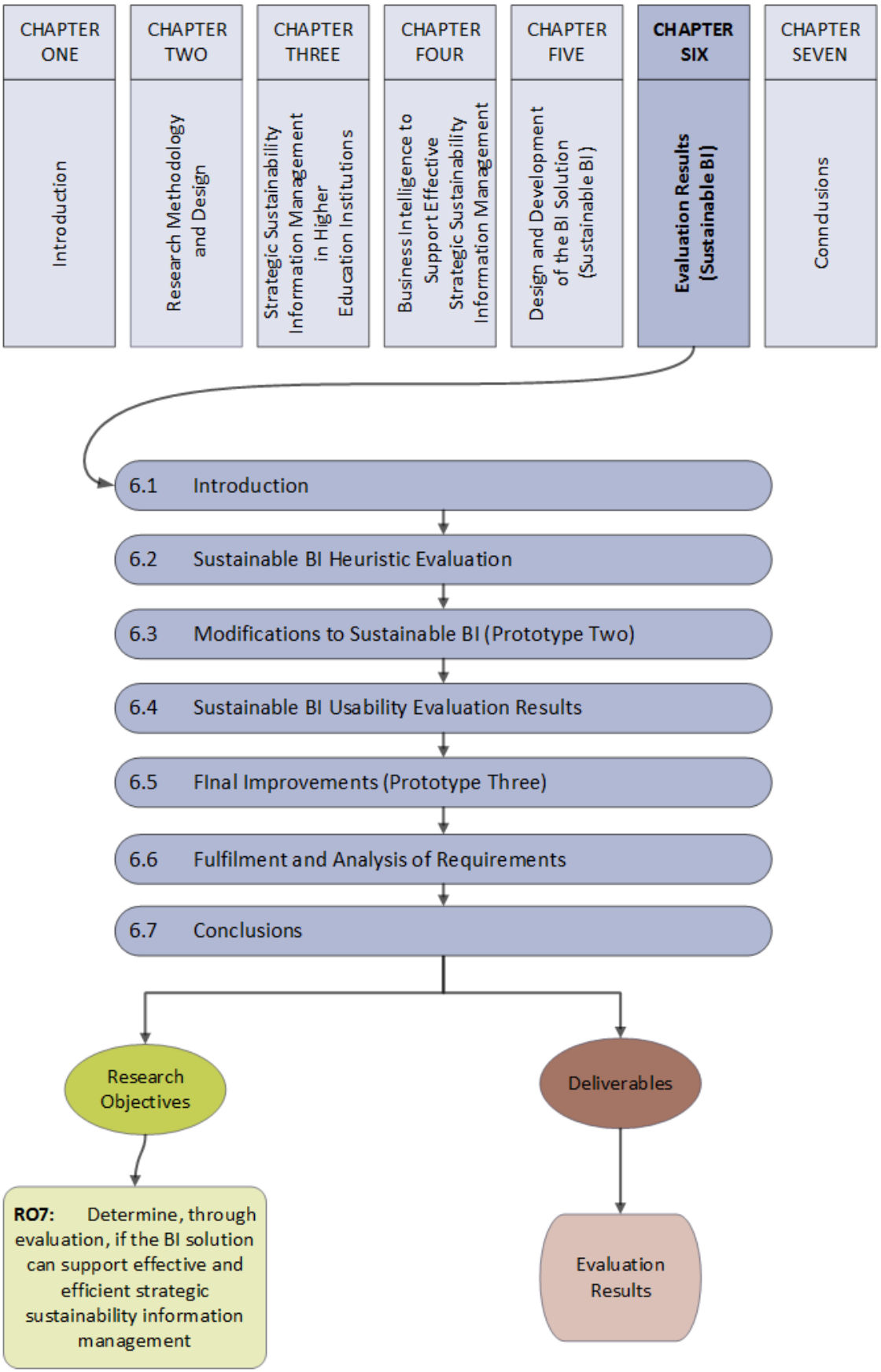

Figure 6-2: Chapter 6 layout

6.2 Sustainable BI Heuristic Evaluation

A heuristic evaluation was conducted to determine heuristic issues with Prototype One of Sustainable BI. Participants were provided with a task list and were required to complete the tasks using Sustainable BI (Section 5.2.2). Participants identified a number of heuristic issues with Sustainable BI, based on the heuristics propsed by Forsell and Johansson (2010) (Figure 6-3). For each issue identified, users were required to provide a brief description of the issue and the severity of the issue, using the heuristics proposed by Forsell and Johansson (2010) (Table 6-1).

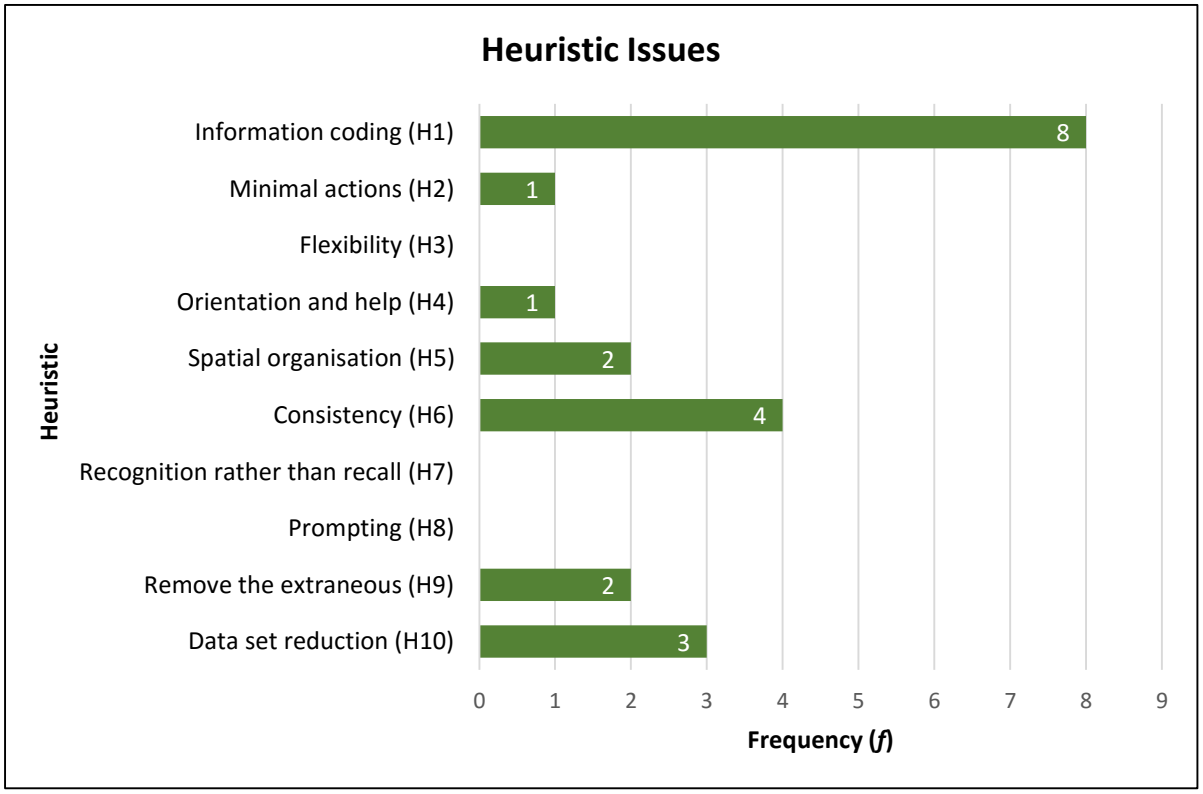

Figure 6-3: Frequency of heuristic issues identified

The results of the heuristic evaluation revealed that there were 21 heuristic issues in total, and the information coding (H1) heuristic had the largest number of issues, with eight issues in this category. The information coding issues related to the lack of measurement units on some graphs, the lack of data labelling on some graphs, and the scaling of the axes of the electricity and water usage graphs. The severity rating of some of the information coding issues was high, with some issues having a severity rating of four. The consistency heuristic (H6) showed the second largest number of issues, with four issues in this category. The issues in the consistency

category were the inconsistency in the use of terms 'pass rate' and 'success rate', and inconsistent labelling.

Table 6-1: Heuristic evaluation problem descriptions

Heuristic	Problem description	Evaluator number	Severity rating	Count
H1 (information coding)	Decrease value of y-axis on electricity usage graph to better show fluctuations in usage	P3	4	8
	Provide unit measurements on graphs	P1	4	
	No units of measurement on electricity and water usage graphs	P5	4	
	Change axis values on "*over time*" graph	P1	3	
	Units of measurement are not provided. Difficult to determine if electricity usage is measured in watts or Rand.	P4	3	
	No data labels on pie charts	P1	2	
	Graphs don't have labels on data points. Need to hover over data points to see values.	P4	2	
	Pie charts should have data labels	P2	1	
H2 (minimal actions)	Difficult to navigate between dashboards. User has to navigate back home to go to another dashboard. Possibly provide tabs to different dashboards.	P4	3	1
H4 (orientation and help)	Provide a home button	P3	2	1
H5 (spatial organisation)	Too much blank space on graduations dashboard	P2	2	2
	Date filters on electricity and water dashboards take up too much space. Dropdowns would be better	P5	2	
H6 (consistency)	Unsure of the difference between pass rate and success rate	P5	3	4
	Inconsistent use of caps and non-caps	P3	1	
	Inconsistent use of terms pass rate and success rate	P3	2	
	Graph labels are inconsistent	P2	1	
H9 (Remove the extraneous)	Remove decimal points	P1	1	2
	Three numbers after decimal point unnecessary	P5	1	
H10	Provide more filters such as gender and race	P3	4	3

(Data set reduction)	Should be more filters than academic year	P2	3	
	Provide additional filters	P1	3	
Total Issues				**21**

The severity ratings in the consistency category were generally low however. The data set reduction (H10) heuristic showed the third highest number of problems, with three problems in this category. All three problems related to the lack of dedicated filters, with most filtering capabilities provided by visualisation interaction. The severity of the data set reduction issues was high.

The spatial organisation (H5) and the remove the extraneous (H9) heuristics had two issues each. The spatial organisation issues related to the misuse of space on the dashboards. Removing the extraneous issues related to the precision of numerical data. Numerical data was too precise and a more rounded numerical data was desirable. The minimal actions (H2) and the orientation and help (H4) heuristics both had only one issue each. The issues with the minimal actions category related to the difficulty in navigating between the different dashboards.

6.3 Modifications to Sustainable BI (Prototype Two)

Modifications were made to sustainable BI based on the heuristic evaluation. The new version of Sustainable BI, with all new modifications, is referred to as Prototype Two. Heuristic issues ranged from low severity issues to high severity issues. The high severity issues were prioritised, and a more detailed explanation of these issues is provided. All issues identified, were fixed.

There were high severity issues with the information coding (H1) heuristic. The information coding issues related to the lack of units provided by the graphs and the axis values of some of the graphs. The information-coding issues were fixed according to the user feedback (Figure 6-4). In Figure 6-4, the top graph is from Prototype One, whereas the bottom graph is from Prototype Two. The y-axis were adjusted to enable users to identify fluctuations and trends better. The units of measurement are also included in the axis of the graph.

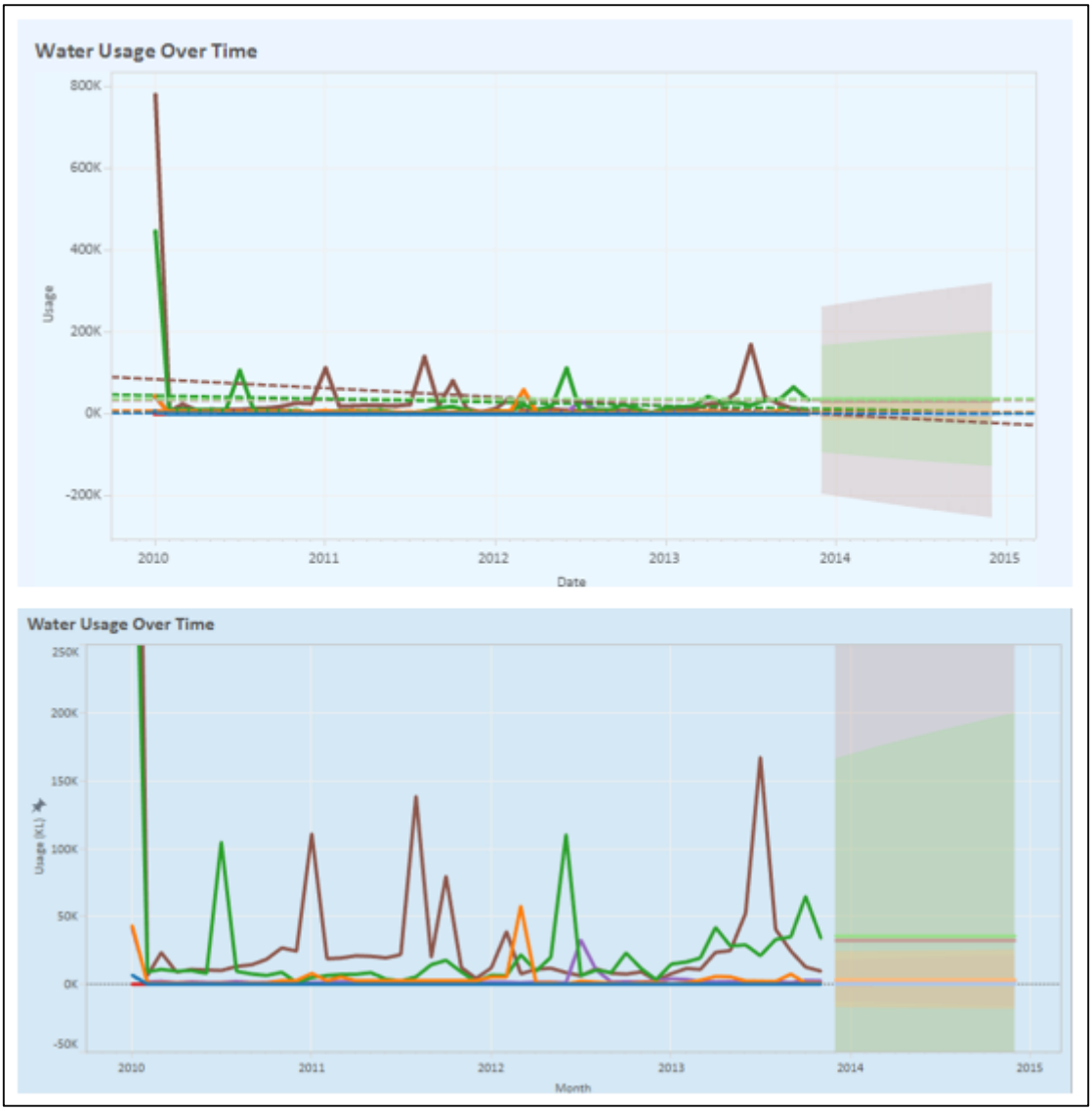

Figure 6-4: Adjustment of y-axis values

Another heuristic with high severity issues was the data-set-reduction heuristic (H10). Prototype One only provided specific filters for the date field. Filtering information by other fields required users to select that specific field on the provided graphs. Users would prefer dedicated filters for fields such as race, gender and nationality. Prototype Two incorporates additional dedicated filters for all the additional fields (Figure 6-5).

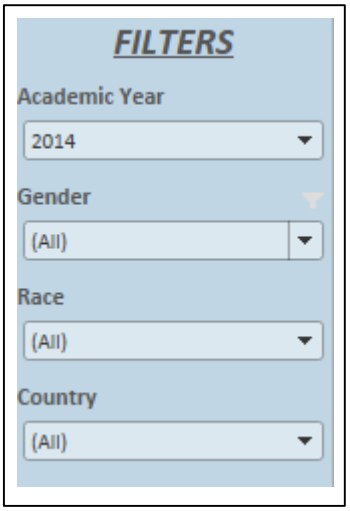

Figure 6-5: Improved filtering capabilities

Consistency issues (H6) include the inconsistent use of capital and non-capital letters, using the terms 'pass rate' and 'success rate' interchangeably, and the inconsistent use of graph labels. There was one recognition rather than recall (H7) issue that was identified by multiple users, namely the lack of labelling on the pie charts. Additional labels were added to the pie charts that enable the user to recognise instantly what each field is (Figure 6-6).

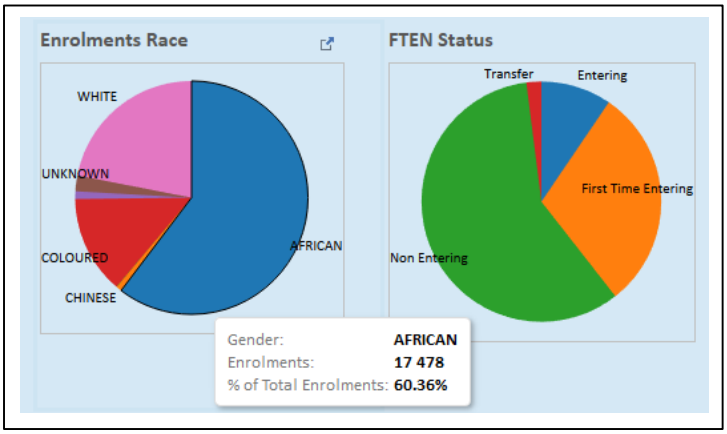

Figure 6-6: Labelling of pie charts

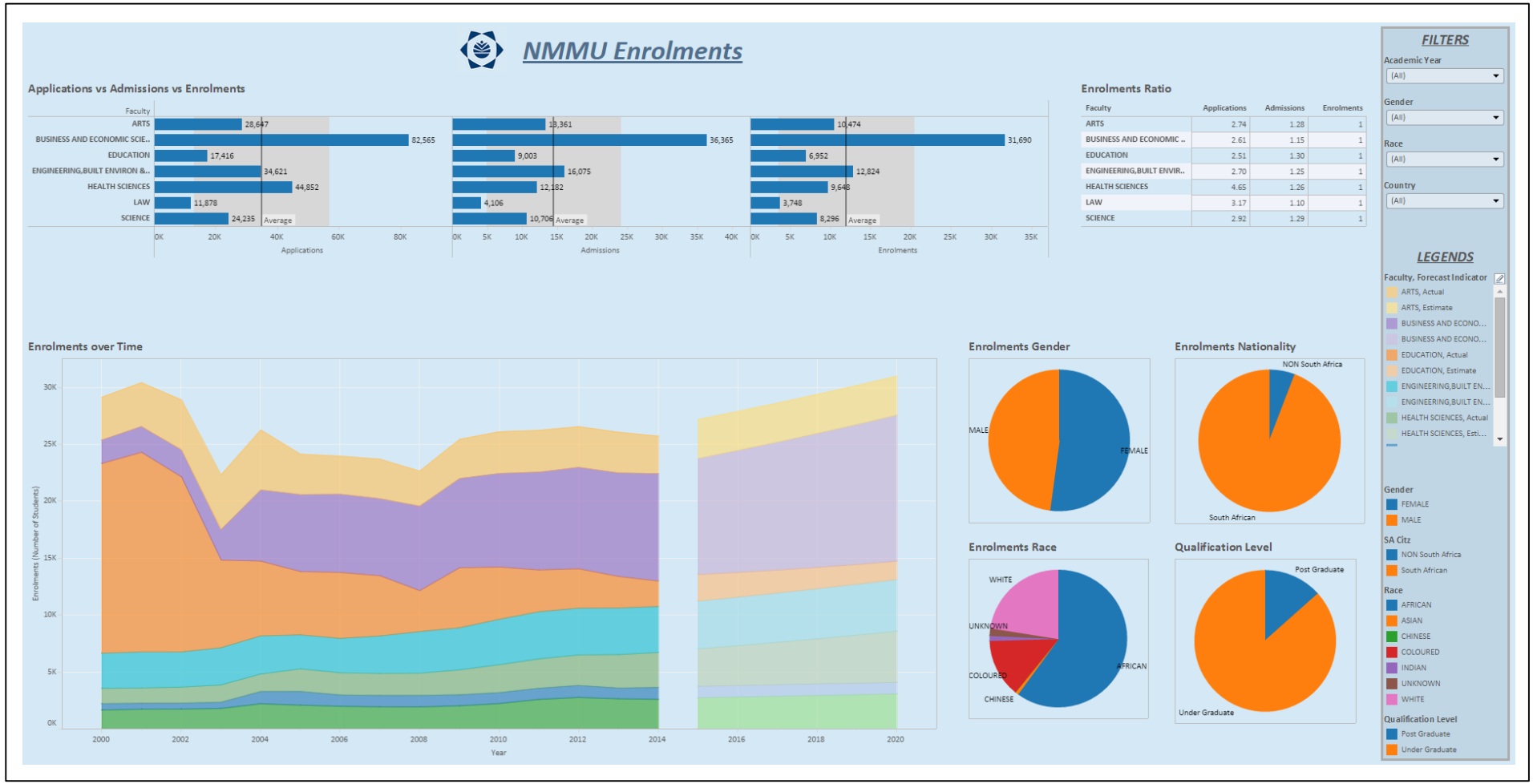

Figure 6-7: Sustainable BI Prototype Two

6.4 Sustainable BI Usability Evaluation Results

Upon completion of the modifications to Sustainable BI recommended in the heuristic evaluation, a full usability study was conducted according to the evaluation plan identified (Section 5.2.2.2). The evaluation plan for the usability study has been previously identified (Section 5.2.2.2). The profile of the participants differed considerably, ensuring that participants with a wide range of skill sets were selected (Section 6.4.1). The results of the evaluation will determine if Sustainable BI is satisfied the predetermined requirements (Section 6.4.2).

6.4.1 Participant Profile

A total of 12 participants completed the usability evaluation. The participants consisted of various management at NMMU, who would be potential users of Sustainable BI. The participants covered a wide age range and consisted of both males and females (Figure 6-8). The age range of the participants varied considerably, with 17% of participants between the ages of 18 and 30, 42% between the ages of 31 and 40, 17% between the ages of 41 and 50, and 25% over the age of 50. The majority of the participants in the study were female, with 77%, whereas there were 23% male participants.

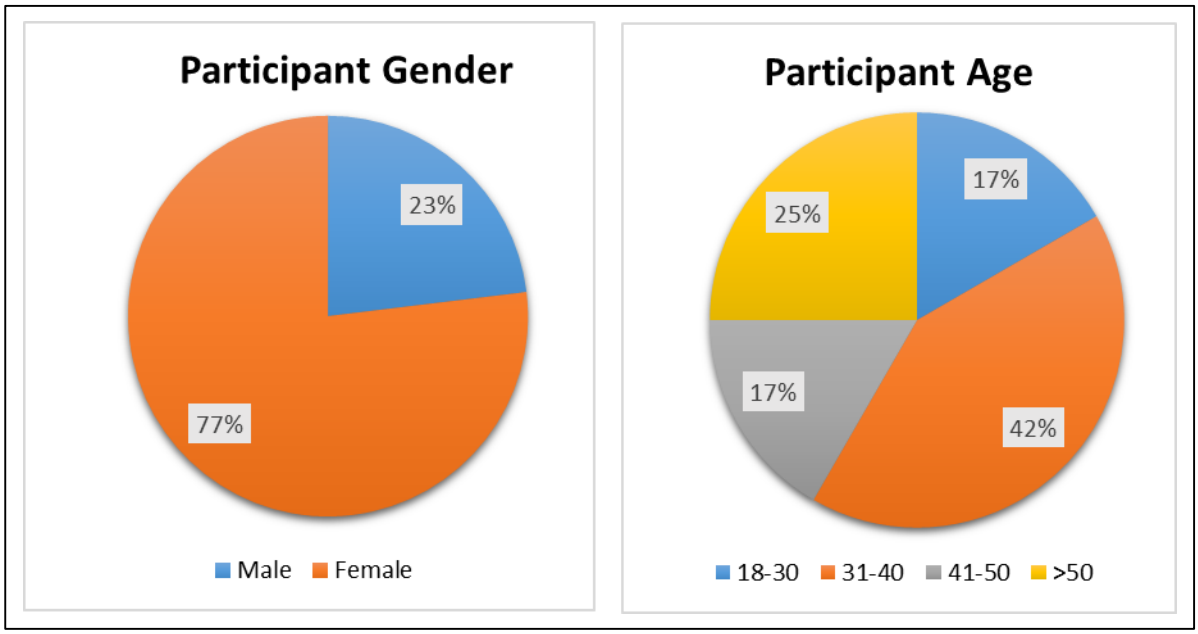

Figure 6-8: Age and gender of participants (n=12)

The majority of the participants in the study had some experience with BI tools and used BI tools frequently (Figure 6-9). Of the participants, 54% had more than five years' experience with using BI tools, 8% had four to five years' experience with BI tools and 15% had less than one year experience with BI tools. The remaining 23% of participants had less than one year experience with BI tools. The frequency of use of BI tools varied considerably between the participants. 38% of participants make use of BI tools daily, 8% of participants make use of BI tools weekly, 23% of participants make use of BI tools monthly, 15% of participants make use of BI tools annually and 15% of participants never make use of BI tools.

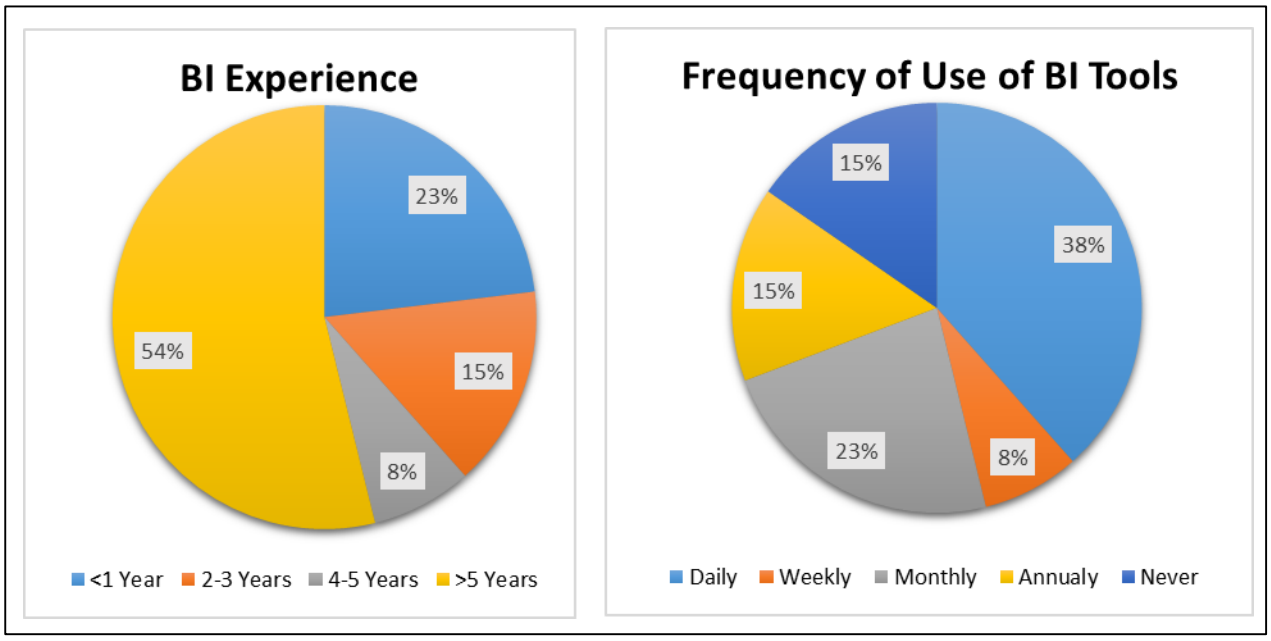

Figure 6-9: Participants' BI experience and frequency of use of BI tools

6.4.2 Evaluation Results [5]

The evaluation results are broken down into the seven BI evaluation metrics identified (Section 5.2.2.2.5). The BI metrics that were identified are visibility (Section 6.4.2.1), flexibility (Section 6.4.2.2), learnability (Section 6.4.2.3), error control and help (Section 6.4.2.4), operability (Section 6.4.2.5), effectiveness and efficiency (Section 6.4.2.6). Users were also required to rate to what extent Sustainable BI can assist in achieving the identified benefits of BI (Section 6.4.2.7). Participants were also required to identify any positive and negative aspects of Sustainable BI (Section 6.4.2.8).

[5] The mean scores are divided into three ranges: Negative = [1 – 2.6); Neutral = [2.6 - 3.4); and Positive = (3.4 - 5].

6.4.2.1 Visibility

The visibility metric consists of four separate statements (Figure 6-10). The highest rated visibility statement is the "*information is displayed in an uncluttered and well-structured manner*" (μ = 4.62), followed by the "*application communicates the system status at all times*" (μ = 4.54) and "*instructions are visible and self-explanatory*" (μ = 4.54). The "*navigation options are clearly displayed*" was the lowest rated statement (μ = 4.38). The participants were satisfied with the visibility of Sustainable BI as all four statements received a mean score in the positive range. The overall mean score for the four visibility statements was in the positive range (μ = 4.52). This indicates that users feel that the information provided by Sustainable BI is highly visible at all times.

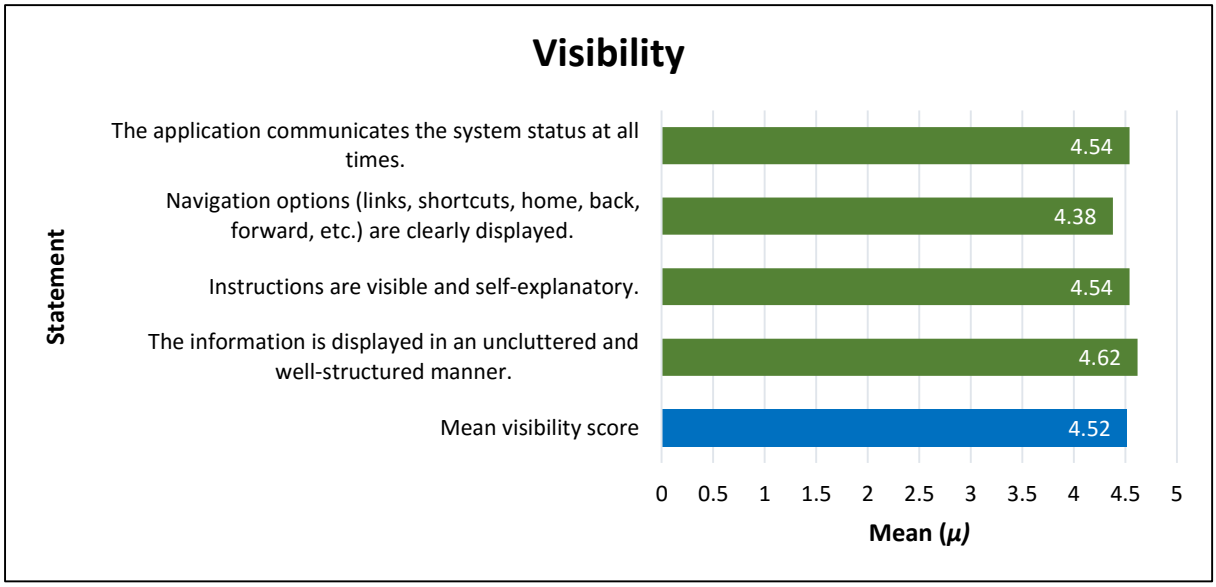

Figure 6-10: Visibility of Sustainable BI

6.4.2.2 Flexibility

The flexibility metric consists of two statements (Figure 6-11). The highest rated aspect is "*the application is customisable for individual or collaborative usage*" (μ = 4.62), followed by "*I felt in control of the application*" (μ = 4.38). Both statements received a mean score above 4, which is in the positive range, indicating that the participants were satisfied with the flexibility of Sustainable BI. The overall mean score for the two visibility statements is in the positive range (μ = 4.5).

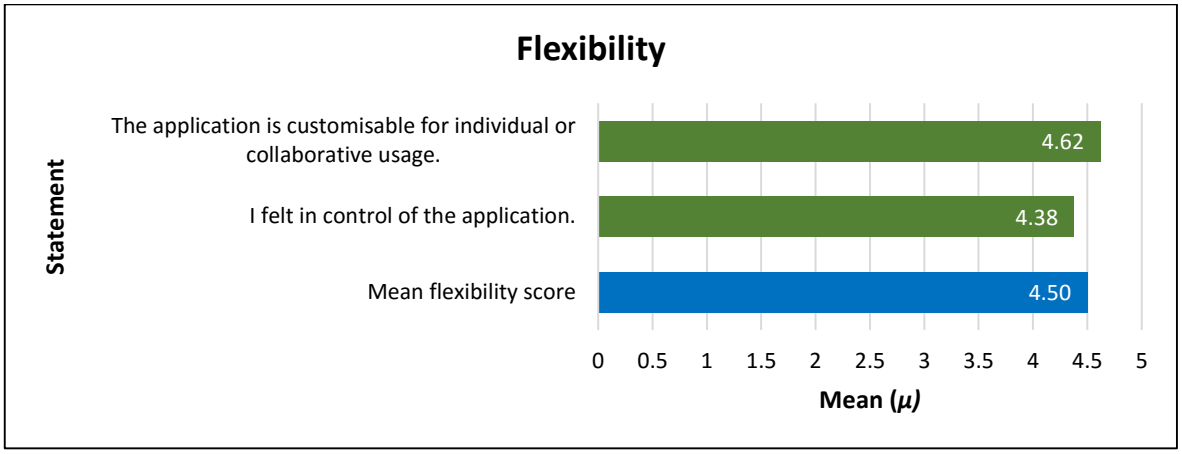

Figure 6-11: Flexibility of Sustainable BI

6.4.2.3 Learnability

The learnability metric consists of four different statements (Figure 6-12). The highest rated statement is "*the terminology used by the application is familiar*" (μ = 4.46), followed by "*the application promotes learnability to make it accessible for infrequent usage*" (μ = 4.38), and "*the application requires limited memory load*" (μ = 4.31). The three statements all received mean scores above 4, which is in the positive range, indicating that participants felt that sustainable BI was easy to learn to use. The evaluation of Sustainable BI revealed that the overall mean learnability score is 4.38, which is positive and shows that Sustainable BI has met the non-functional requirement "*the BI solution must be easy to learn to use*" (R9).

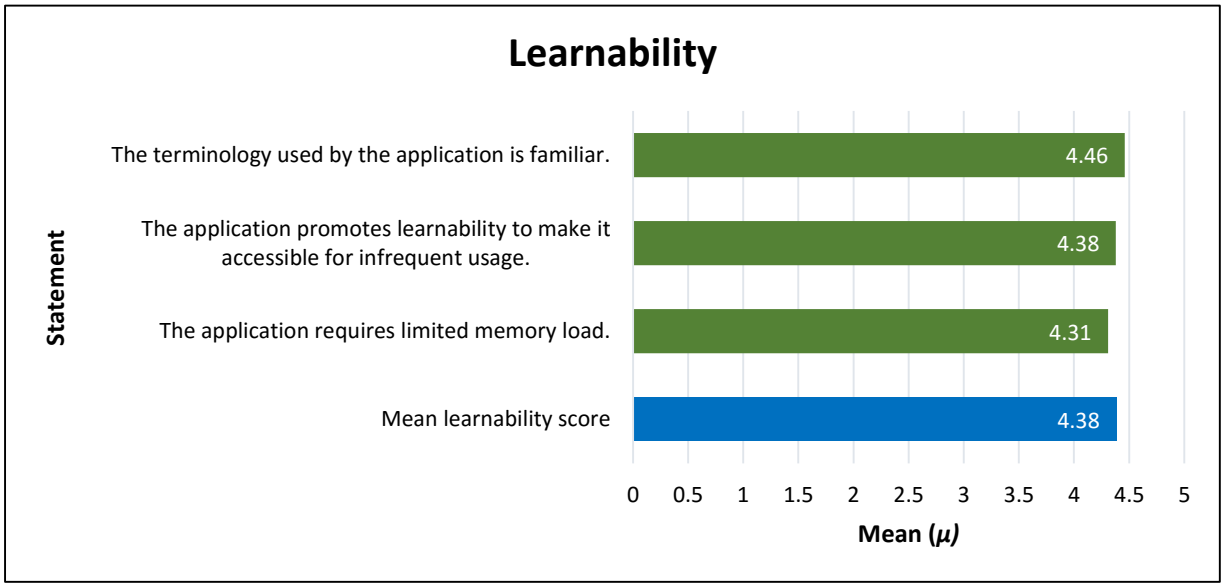

Figure 6-12: Learnability of Sustainable BI

6.4.2.4 Error Control and Help

The error control and help metric consists of two statements (Figure 6-13). The highest rated statement is "*the application provides user support*" (μ = 4.08), followed by "*the application makes provision for error prevention and recovery*" (μ = 4). The overall mean error control and help score is 4.04, which is in the positive range, but is the lowest mean score of all the usability metrics.

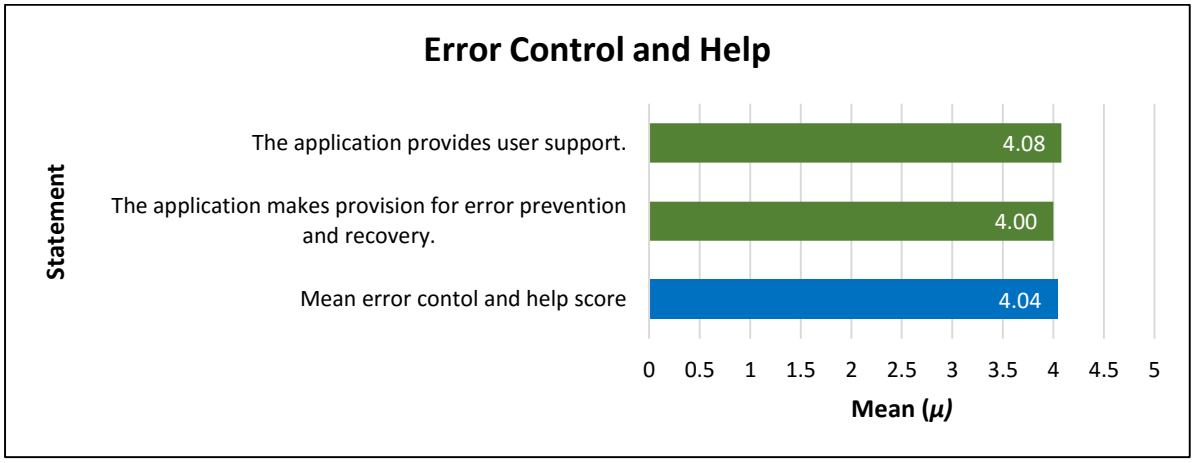

Figure 6-13: Error control and help of Sustainable BI

6.4.2.5 Operability

The operability metric consists of eight statements (Figure 6-14). The highest rated statements are "*I have the option to save data views on the application*" (μ = 4.92) and "*the application allows knowledge sharing and exporting data"* (μ = 4.92). This is followed by "*the application behaviour is consistent*" (μ = 4.85) and "*there is an information visualisation functionality*" (μ = 4.85), "*data is accessible on different levels of aggregation*" (μ = 4.77), "*filters applied to data are highly visible at all times*" (μ = 4.69). The lowest ranked statement is "*the system displays a hierarchical map to determine data granularity level*" (μ = 4.54). All operability mean scores are above 4.5 with an overall mean operability score of 4.77, which is in the positive range, indicating that participants are very satisfied with the operability of Sustainable BI.

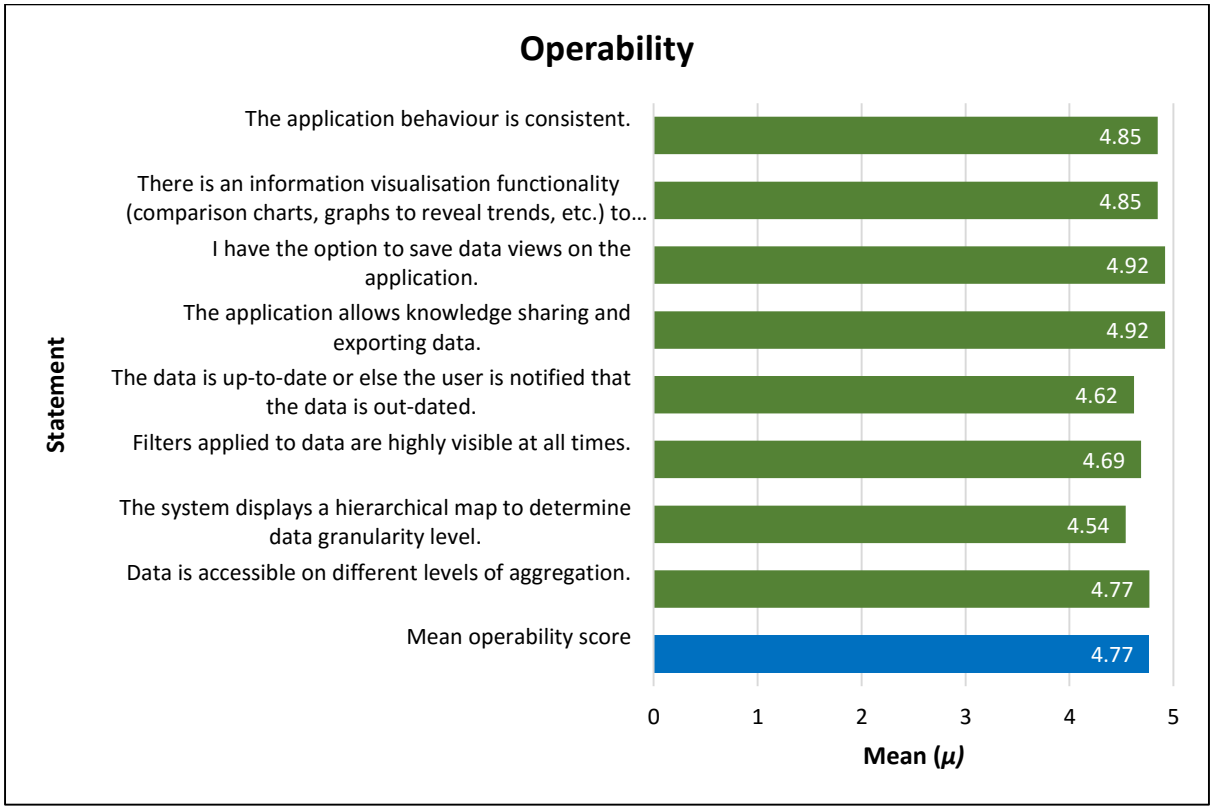

Figure 6-14: Operability of Sustainable BI

6.4.2.6 Effectiveness and Efficiency

The effectiveness of Sustainable BI is measured by two methods. The first method was through the post-task questionnaire, which contained an effectiveness category (Figure 6-15). Participants were required to answer questions for each task based on the information provided by Sustainable BI. The second method for measuring effectiveness is through the accuracy of the answers provided by the participants. The more accurate the answers, the more effective Sustainable BI is.

In the post-task questionnaire, the effectiveness metric consists of two statements "*I could effectively complete tasks and scenarios using the system*" and "*I could complete all the tasks successfully using the system.*" Both statements were rated 4.69, meaning the overall mean effectiveness score is 4.69.

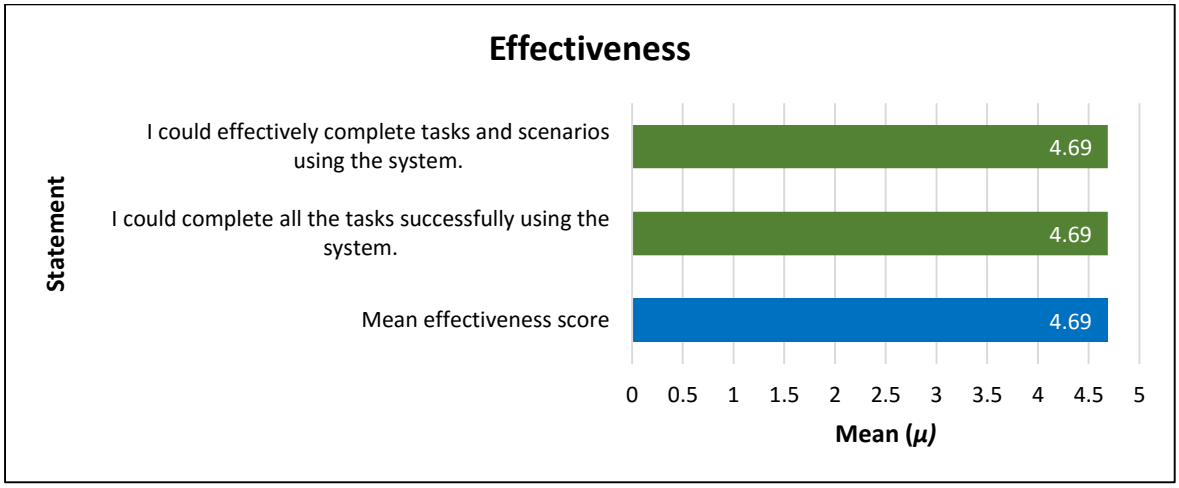

Figure 6-15: Effectiveness of Sustainable BI

The effectiveness of the system can also be measured by the accuracy with which the participants completed the given tasks (Figure 6-16). Each task in the task list required the user to answer a question related to the given task. The participant's answer would reveal whether they have successfully completed the task or not. Three of the tasks had a success rate of 100%, three tasks had a success rate of 92%, and one of the tasks had a success rate of 85%. The high success rates of the tasks suggests that the Sustainable BI is an effective tool.

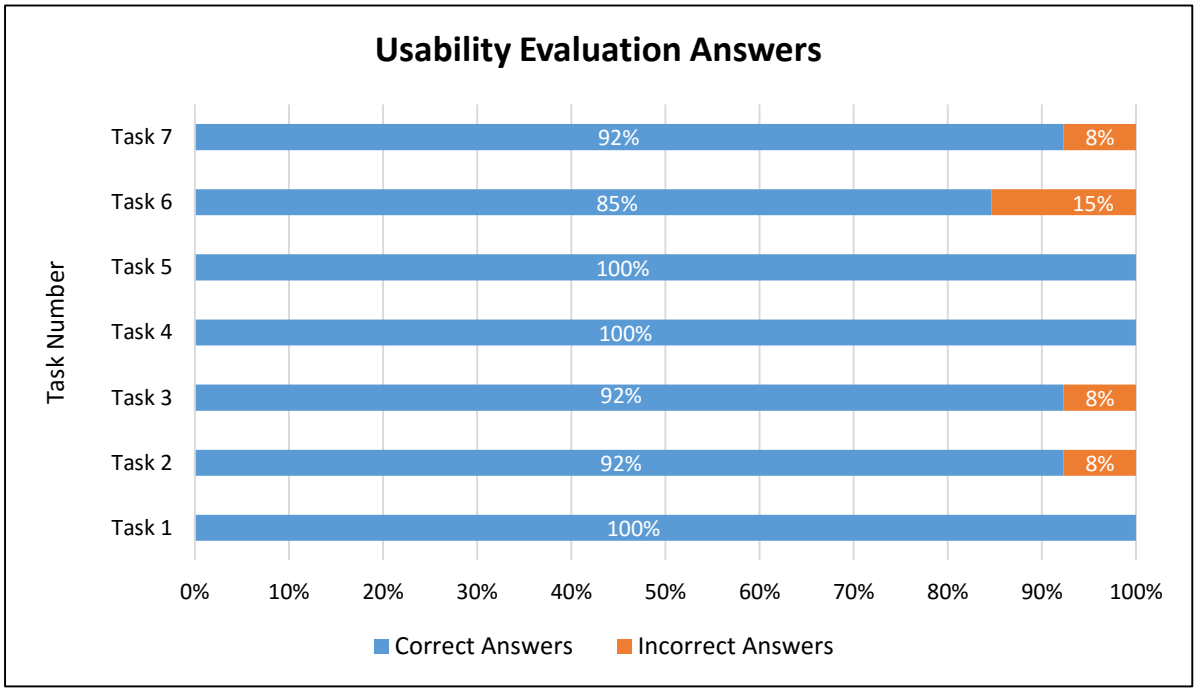

Figure 6-16: Sustainable BI task success

The efficiency category consists of three statements. The highest rated statement was "*the application provides a rapid response rate*" (μ = 4.77), followed by "*I was able to efficiently complete the tasks and scenarios using the system*" (μ = 4.54), and "*I was able to complete the tasks and scenarios quickly using the system"* (μ = 4.46). All three statements were scored 4 or above, which is in the positive range, indicating that participants were satisfied that Sustainable BI was efficient in accomplishing the required tasks.

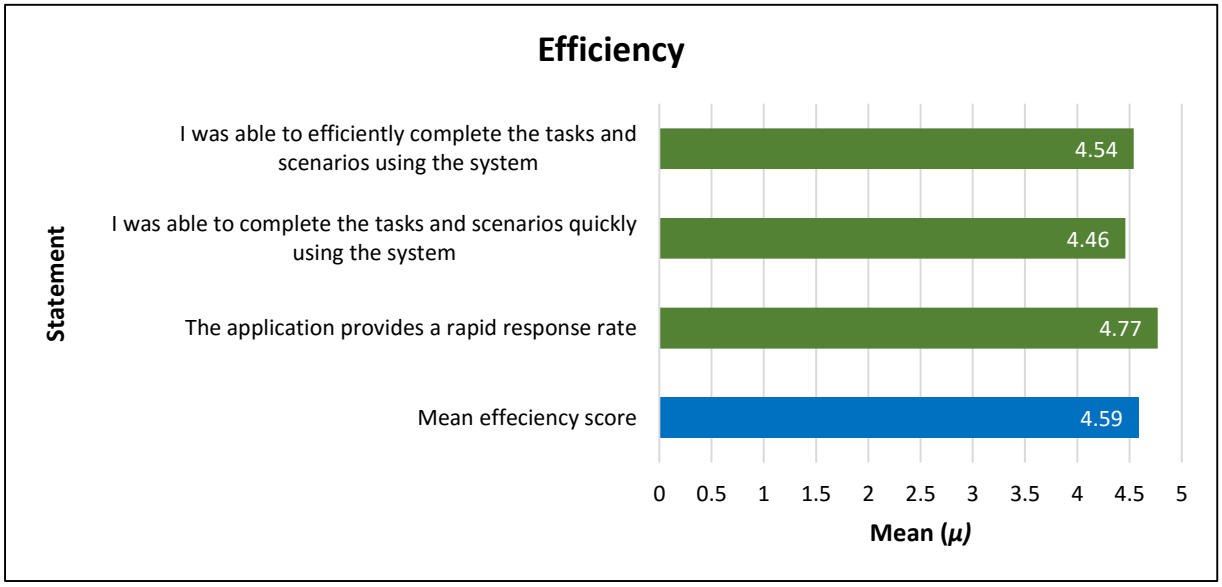

Figure 6-17: Efficiency of Sustainable BI

6.4.2.7 Benefits of BI

The participants were also asked to rate to what extent they felt that sustainable BI could help realise the benefits of BI identified by literature (Figure 6-18). The feedback provided by the users was very positive, with many participants indicating that they would make use of Sustainable BI. All the mean scores for the benefits that Sustainable BI could provide are above 4.5, which is in the positive range. The highest rated benefits are "*the system provides me with integrated information*", "*the system can help improve organisational performance*" and "*the system provides me with better decision-making capabilities*" (μ = 4.85). This is followed by "*the system provides improved support for managing strategic goals*" and "*the system provides more and better information*" (μ = 4.77).

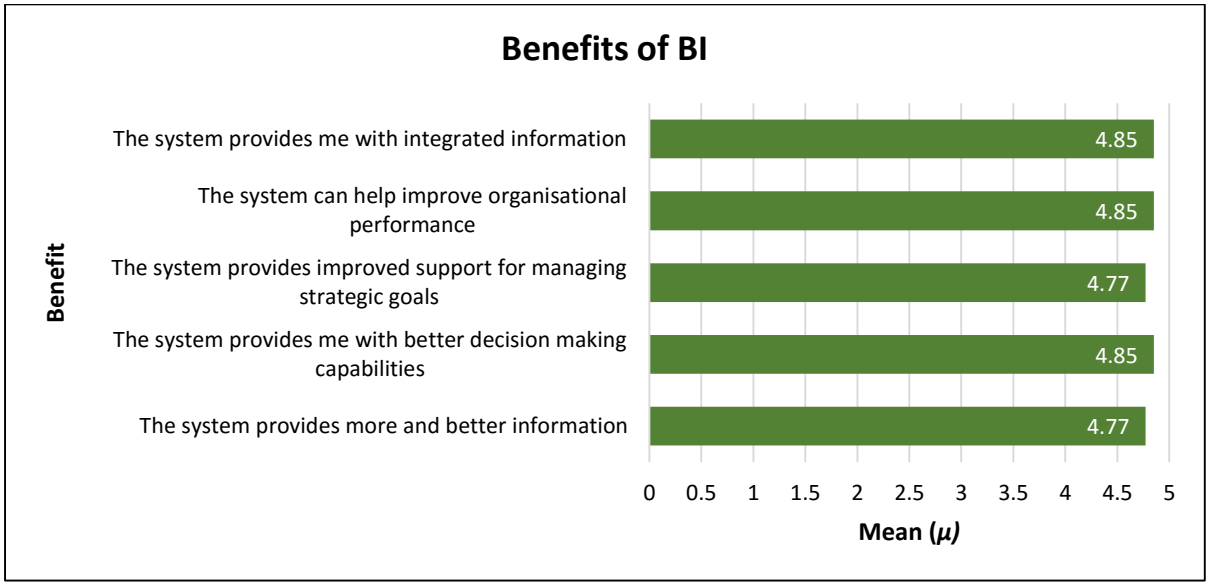

Figure 6-18: Benefits of Sustainable BI

Theory suggests that BI assists an organisation in realising a number of benefits (Section 4.5). The results of the evaluation confirm that Sustainable BI can assist NMMU in realising all the benefits identified as all the benefits received mean scores in the positive range.

6.4.2.8 Positive and Negative Aspects of Sustainable BI

The post-task questionnaire also required participants to list any positive or negative aspects of Sustainable BI (Table 6-2). Both the positive aspects and negative aspects (Table 6-3) were grouped into related themes using thematic analysis, using the approach identified by (Braun and Clarke, 2006). The positive aspect with the highest frequency was that "Sustainable BI is intuitive an easy to use" (*f*=3). This corresponds directly to the non-functional requirement that "*the BI solution must be easy to use".* Sustainable therefore has met this requirement.

All the other positive aspects were identified by two different participants (*f*=2). The other positive aspects were that "*the forecasting and drill-down capabilities are very useful*", Sustainable BI *"allows for improved decision-making*", Sustainable BI *"enables transformation of raw data into useful information*", and "*the dashboards are a good way to visualise data (identify trends)".* These aspects all align directly to the requirements for a BI solution to support strategic sustainability information in higher education.

Table 6-2: Positive aspects of Sustainable BI identified by participants

Positive Aspect	Frequency (*f*)
Sustainable BI is intuitive and easy to use	3
Forecasting and drill-down capabilities are very useful	2
Allows for improved decision-making	2
Enables transformation of raw data into useful information	2
Good way to visualise data (identify trends)	2

The negative aspects identified by the participants were that the response times of Sustainable BI are slow (*f* = 3), the information does not all fit on one screen as the dashboards are too wide (*f* = 2) and filters should be at the top not the side. The slow response time of Sustainable BI can be explained by the volatility of the internet connection at NMMU. As Sustainable BI is a cloud-based solution, it is entirely dependent on the speed of the internet connection. Some participants may have experienced slow internet speeds where others might not have. While participants found that the response times of Sustainable BI are slow, they could still complete tasks efficiently (Section 6.4.2.6). Some participants felt that the dashboards are too wide and they would prefer a narrower dashboard. Participants would also prefer filters to be at the top of the screen rather than on the right.

Table 6-3: Negative aspects of Sustainable BI identified by participants

Negative Aspect	Frequency (*f*)
Response times are slow	3
Information does not all fit on one screen (dashboards too wide)	2
Filters should be at the top of the dashboard not the side	2

6.5 Final Improvements (Prototype Three)

Based on the results of the usability evaluation, final improvements were made to Sustainable BI. The final improvements were all minor in nature. The following usability problems were discovered and addressed (Figure 6-19):

- The dashboards were made narrower so that users can more easily find information; and
- Filters were added to the top of the dashboard, so that they are more visible.

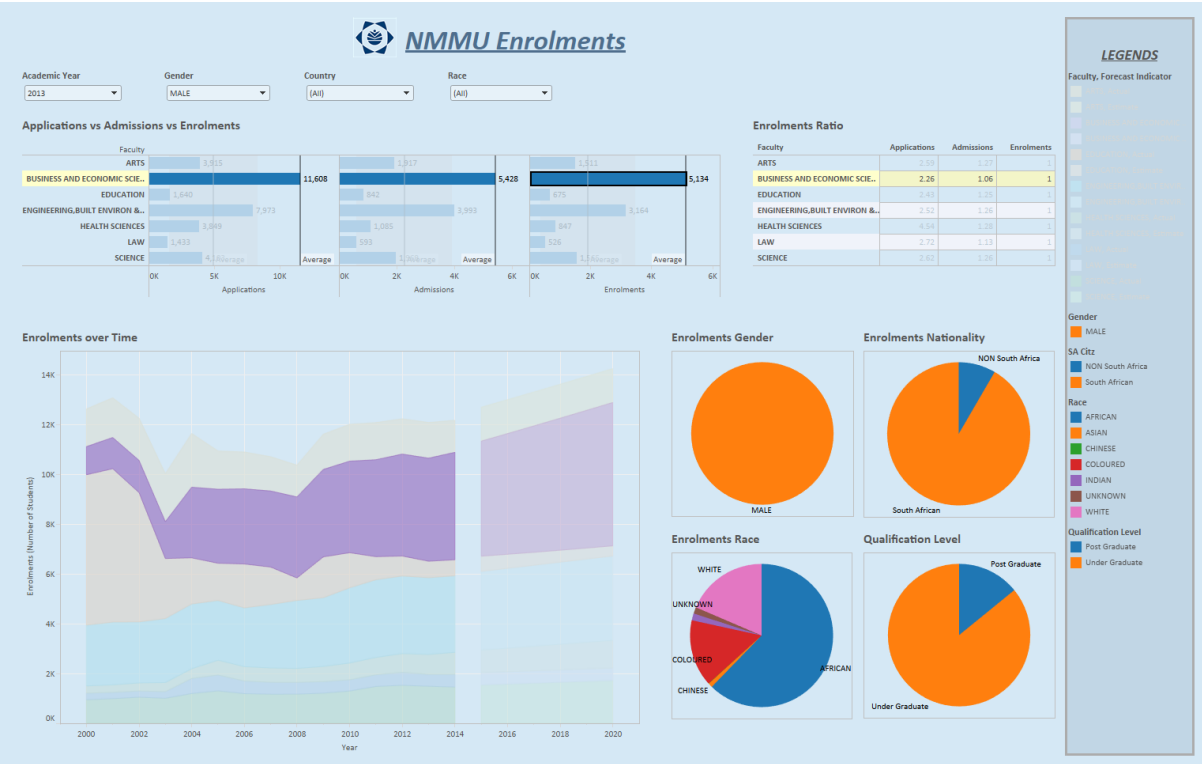

Figure 6-19: Sustainable BI Prototype Three

One of the negative comments that were not addressed in Prototype Three was the response times of Sustainable BI. Sustainable BI was hosted on the Tableau servers and therefore required a stable internet connection. The response times at NMMU could be improved by hosting Sustainable BI on an NMMU server so that the speeds are not negatively affected by the unstable internet connection.

6.6 Fulfilment and Analysis of Requirements

The high-level objectives, functional requirements and non-functional requirements of Sustainable BI were identified (Section 4.10). The high-level objectives are that Sustainable BI should provide up-to-date strategic sustainability information based on NMMU's KPIs, the information should be both historic and predictive, and the application should support the sharing of information. All the high-levels objectives have been met as Sustainable BI provides dashboards with up-to-date information based on the KPIs identified in the NMMU Vision 2020. Sustainable BI also provides not only historic information, but also uses forecasting capabilities to provide predictions. The participants could also create CSV and PDF reports to enable the sharing of information.

The functional requirements of BI solution to support strategic sustainability information management were also met as Sustainable BI provides all the functionality that was identified. Sustainable BI provides dynamic and interactive dashboards that provide up-to-date sustainability information based on strategic KPIs at NMMU. The information is aggregated into a high-level of granularity, however drill-down capabilities enable users to view information at a lower granularity to identify the root cause of specific problems. The information provided by Sustainable BI covers both the educational and environmental aspects of sustainability, by integrating environmental and educational data sources. Sustainable BI also provides predictive capabilities through the use of forecasting.

The results of the usability evaluation indicate that the non-functional requirements of Sustainable BI were also met. The evaluation results indicated that participants could repeat all the required tasks efficiently and effectively, with mean scores of 4.59 and 4.69 respectively (Figure 6-20). This indicates that Sustainable BI satisfied the requirements that "*the BI solution must provide information to users in an effective manner*" (R11) and "*the BI solution must provide information to users in an efficient manner*" (R12). Sustainable BI also had a high learnability an overall mean score of 4.58, indicating that sustainable BI achieved the requirement that "*the BI solution must be easy to learn*"(R10) .

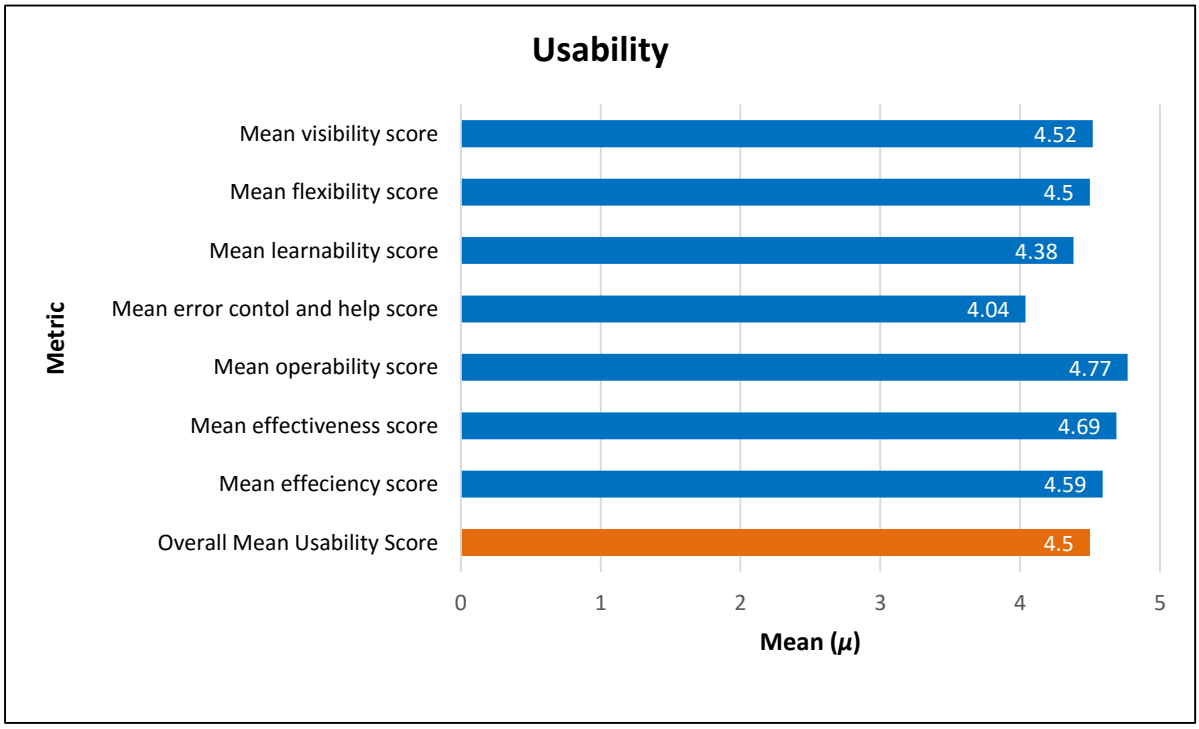

Figure 6-20: Overall mean scores for all metrics

6.7 Conclusions

This chapter focusses on the fourth and fifth stages of the DSR process, namely demonstration and evaluation. The artefact, Sustainable BI, was demonstrated to the relevant stakeholders and then evaluated through a heuristic evaluation and a usability study. The heuristic evaluation was conducted first to determine heuristic issues with Sustainable BI. The heuristic evaluation revealed that the majority of the issues with Prototype One of Sustainable BI were related to information coding. The problems identified by BI experts in the heuristic evaluation were corrected, which led to the development of Prototype Two of Sustainable BI. A full usability study of Sustainable BI was conducted to assist in determining if Sustainable BI could assist in more effectively and efficiently managing strategic sustainability information management.

The research question to be answered by this chapter was:

RQ_8: To what extent can the implemented BI solution support effective and efficient strategic sustainability information management in HEIs?

The results of the evaluation revealed that Sustainable BI can assist strategic management in the better management of strategic sustainability information. The mean scores for all metrics were above 4, which is in the positive range, indicating that users were satisfied with all areas of Sustainable BI (Figure 6-20). The efficiency and effectiveness overall mean scores were 4.59 and 4.69 respectively, indicating that Sustainable BI could support effective and efficient sustainability information management.

Chapter 7. Conclusions

7.1 Introduction

The previous chapter discussed the results from the evaluation of the Sustainable BI prototype.

In order to determine whether the study can be considered successful, the research objectives need to be reviewed (Section 7.1). Several theoretical and practical contributions of the study are identified (Section 7.3). A few problems and limitations were experienced during this study (Section 7.4). Whilst the study can be considered successful and provides valuable contributions, there are still possibilities for future research (Section 7.5), and three artefacts were produced (Section 7.6). This chapter addresses the sixth and final stage of the DSR process, namely communication and reflects on the findings of the research (Figure 7-1). Findings from the research were also presented through conference papers (Appendix E). The full outline of the chapter is provided in Figure 7-2.

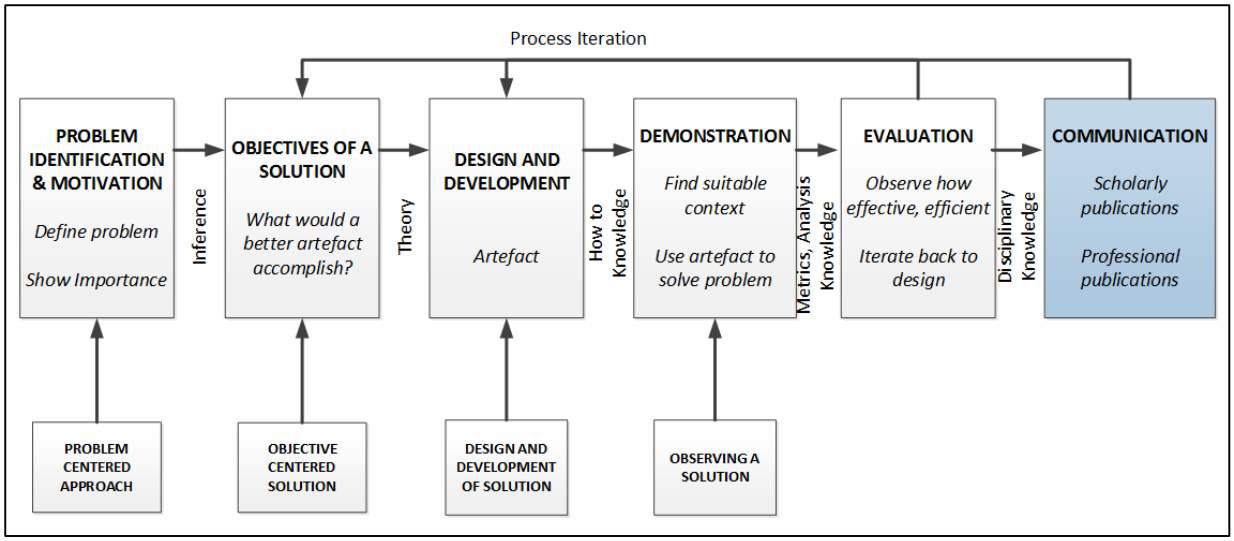

Figure 7-1: Communication stage of the DSR process (Peffers et al., 2006)

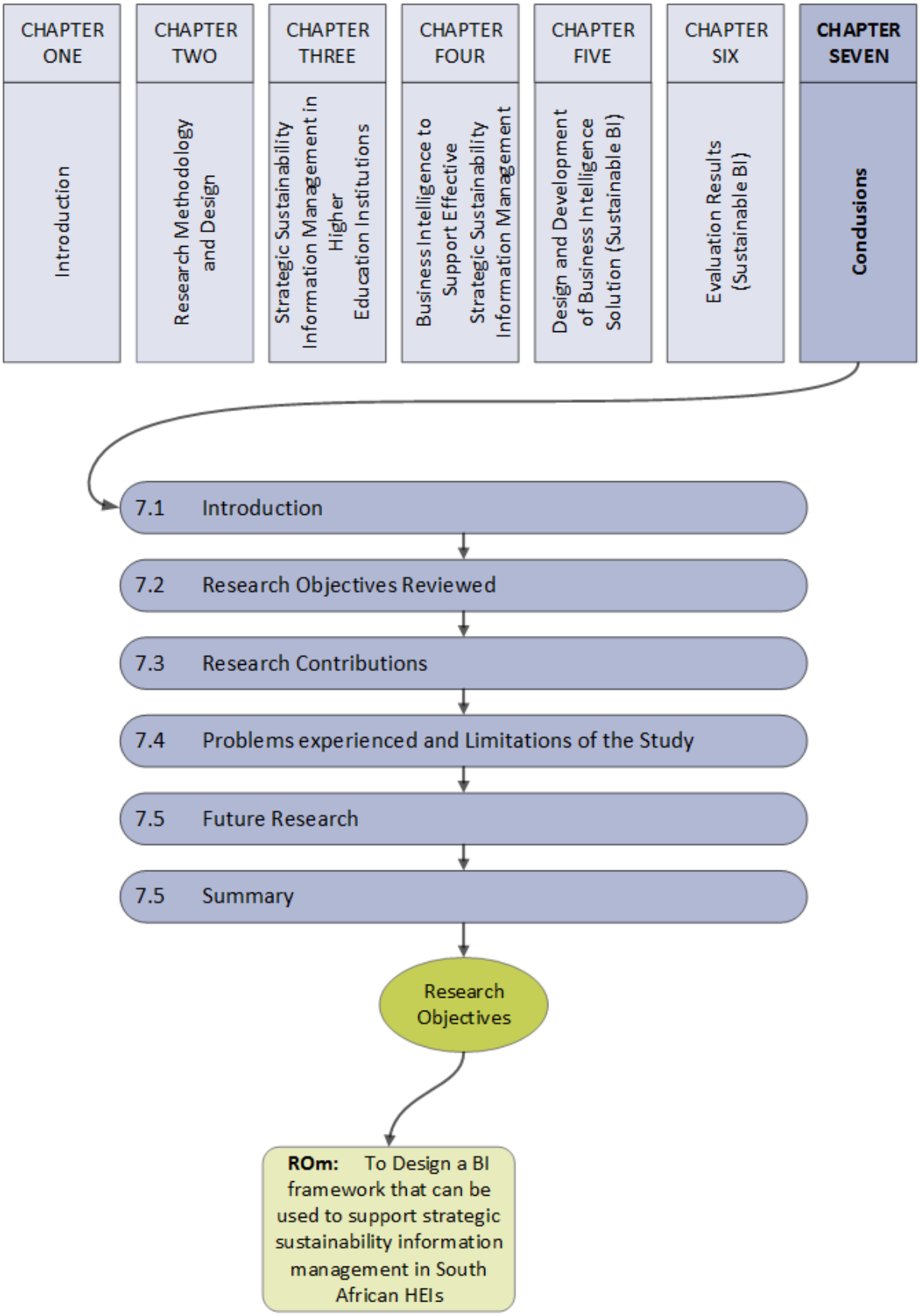

Figure 7-2: Chapter 7 layout

7.2 Research Objectives Reviewed

The first research objective (RO_1) in this study was to identify the drivers of sustainability in HEIs (Section 3.3). Internal drivers of sustainability include risk identification and resource and cost savings. External drivers of sustainability include regulatory compliance, external stakeholder pressure and the reputation of the organisation.

The second secondary objective (RO_2) in this study was to identify the constraints to effective sustainability management in HEIs (Section 3.8). The constraints to effective sustainability management relate to management and people as well as information and ISs. The focus of this research is the Information and IS constraints and therefore these constraints were validated through structured interviews with the relevant stakeholders at NMMU (Section 5.3.1). The interviews revealed that the biggest information and IS constraints to effectively managing strategic sustainability at NMMU are siloed data and information, and poor sharing and communication of information. This was followed by the lack of sustainability data access, the overlapping of data and the unavailability of data.

The third research objective (RO_3) in this study was to identify the strategic sustainability indicators at NMMU. The strategic primary sustainability indicators at NMMU cover multiple aspects of sustainability and include indicators such as the applications to admissions to enrolments ratio, the target success rate for all the modules offered by the university and the environmental indicators such as water and electricity usage.

The fourth research objective (RO_4) in this study was to identify the benefits and challenges of BI, which is the proposed solution to overcome the constraints to effectively managing strategic sustainability information (Section 4.5). The challenges to implementing a BI solution were validated through structured interviews with the relevant stakeholders at NMMU (Section 5.3.2). The biggest challenges to implementing a BI solution are the lack of IT support and poor organisational alignment. Other challenges are the complexity of the BI tools, the high cost of implementation and the quality of the data. The benefits of BI are more and better information, better decision-making capabilities, improved support of strategic goals, improved organisational performance and integrated information.

The fifth research objective (RO_5) in this study was to identify the CSFs for BI (Section 4.6). The CSFs for BI were identified and validated with the relevant stakeholders at NMMU

through structured interviews (Section 5.3.3). The interviews revealed that the most important CSFs for BI are having a clear vision and well-defined requirements of the system, committed management and support, and aligning the BI strategy with business objectives. Other CSFs are having a committed and informed executive sponsor, having the appropriate team skills, adequate resources, effective data management, user-oriented change-management, project scope management, and a flexible and appropriate framework.

The sixth research objective (RO_6) in this study was to identify the objectives and requirements of a BI solution to support strategic sustainability information management in HEIs. The requirements of the BI solution were established through an analysis of existing literature and by conducting interviews with the relevant stakeholders at NMMU. The analysis of existing literature and interviews led to the development of a number of functional and non-functional requirements for a BI solution to support strategic sustainability information management (Table 4-6). An extant-systems analysis revealed that three of the requirements were not met by the existing BI solution at NMMU, InfoPoint. The three requirements not satisfied by InfoPoint were: providing dynamic and interactive dashboards, providing predictive/forecasting capabilities, and covering more than one aspect of sustainability. The proposed BI solution, Sustainable BI, should incorporate the existing functionality provided by InfoPoint, as well as the additional three requirements not satisfied by InfoPoint.

The seventh research objective (RO_7) in this study was to identify how a BI solution to support strategic sustainability information management should be designed and evaluated. Sustainable BI was developed based on the proposed BI framework. An architecture for Sustainable BI and the metrics to evaluate Sustainable BI were also proposed. These metrics against which Sustainable BI will be measured are visibility, flexibility, learnability, error control and help, operability, effectiveness and efficiency.

The eighth research objective (RO_8) in this study was to determine if BI can support effective and efficient strategic sustainability information management. The BI prototype that was iteratively developed, Sustainable BI, was evaluated by means of a heuristic evaluation and a usability evaluation. The purpose of the usability evaluation was to examine the usability of the Sustainable BI prototype, and determine whether the prototype can support effective and efficient strategic sustainability information management.

7.3 Research Contributions

This contributions of this were both theoretical (Section 7.3.1) and practical (Section 7.3.2).

7.3.1 Theoretical Contributions

The key theoretical contributions of this research, identified through a literature review, are:

- The drivers of sustainability in HEIs (Figure 3-4);
- The constraints to effective sustainability management (Table 3-4);
- The benefits and challenges of BI (Section 4.5);
- The CSFs for BI (Table 4-3);
- A Sustainability Management Model (Figure 4-10); and
- A BI framework to support strategic sustainability information management (Figure 7-3).

The Sustainability Management Model can be broken up into two categories, namely the sustainability component and the BI component. The sustainability component consists of the drivers of sustainability in HEIs and the constraints to effective sustainability management.

There are two broad categories of constraints to effective sustainability management, namely information and IS, and management and people. The focus of this research was to manage strategic sustainability information more effectively, and therefore greater focus was placed on the information and IS constraints. Key stakeholders at NMMU were asked to rank the information and IS constraints based on the extent to which they are constraints to managing strategic sustainability at NMMU. The results revealed that the most severe constraints to information and IS are siloed data and information and poor communication of information.

The BI component of the Sustainability Management Model consists of the benefits of the challenges of BI, and the CSFs for BI. The challenges of BI should be considered before embarking on any BI project. The challenges of BI were validated by the relevant stakeholders at NMMU through structured interviews. The interviews revealed that the biggest challenge to implementing BI is the lack of dedicated IT support, followed by poor organisational alignment, the complexity of the BI tools, the high cost of the tools and their implementation, and the quality of the data. The benefits of BI are the ability to provide more and better information to management, providing management with better decision-making capabilities,

improved support of strategic goals, improved organisational performance and integrated information. The model is a theoretical model that provides management with an overview of all the interrelated components that should be considered when undertaking the task of managing sustainability information more effectively.

In order to ensure the success of any IT project, CSFs should be identified beforehand and followed. This is no different to a BI project. A number of CSFs for BI were identified through a literature analysis. The relevant stakeholders at NMMU were asked to rank the CSFs based on the extent to which they feel the factor is critical to the success of a BI project. The factor deemed most important to the success of a BI project is a clear vision and well defined requirements. Other highly ranked factors were committed management support, aligning the BI strategy with business objectives, a committed and informed executive sponsor and having the appropriate team skills.

The main contribution of this study is therefore the BI framework to support strategic sustainability information management in HEIs (Figure 7-3). The BI framework was proposed after an analysis of existing literature, as well as conducting interviews with the relevant stakeholders at NMMU to determine the requirements for a BI solution to support effective strategic sustainability information management.

Version 3 of the proposed BI framework, expands on version 2 of the framework (Figure 4-16) to include the six step dashboard development process (Figure 4-8). Management are responsible for steps one to three of the process, in which the high-level objectives are set, the tasks, competencies and responsibilities are defined, and the indicators are set. Step four of the process involves collecting the data and information based on the indicators identified in step three. Typically the data collection systems are set-up by the IT team. The IT team is also responsible for step five of the process, in which the dashboards are developed. These dashboards are developed based on the indicators identified in step three, and make use of the data and information collected in step four. The final step of the process is to evaluate the dashboards. Typically the potential users of the dashboards will be required to evaluate the dashboards.

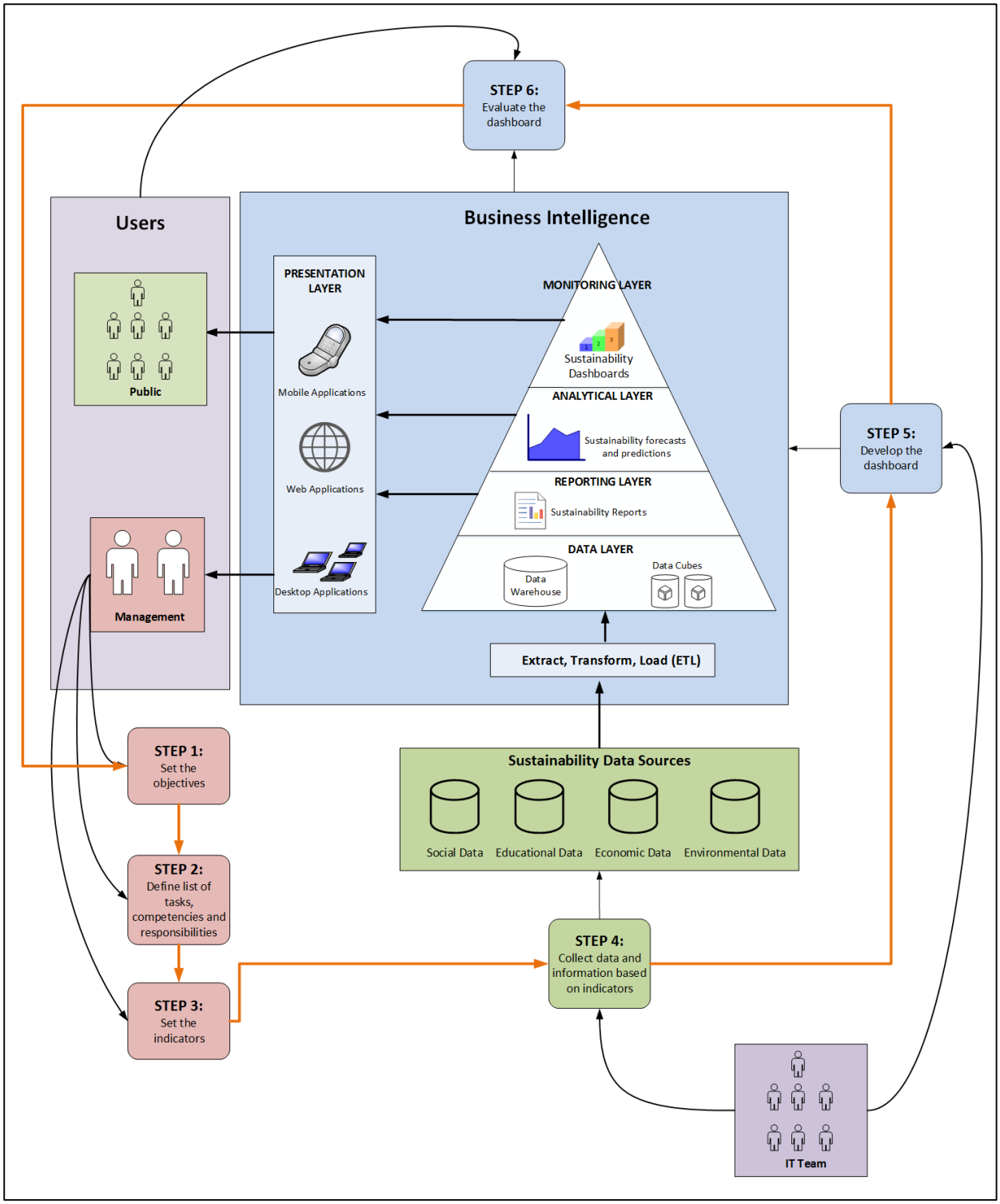

Figure 7-3: BI framework for strategic sustainability information management in higher education (version 3)

7.3.2 Practical Contributions

The practical contribution of this study is the Sustainable BI prototype, which can be used by management in higher education to support strategic sustainability information management.

Sustainable BI satisfies all the requirements identified for a BI solution to support strategic sustainability information management, including the requirements not satisfied by NMMU's existing BI solution, InfoPoint. Sustainable BI provides dashboards that cover both the educational and environmental aspects of sustainability. The architecture of sustainable BI was developed based on the proposed BI framework to support effective strategic sustainability information management.

The Sustainable BI prototype was evaluated through a usability evaluation to determine to what extent it could support the effective management of strategic sustainability information. The results of the evaluation revealed that the Sustainable BI prototype was very successful in effectively and efficiently managing strategic sustainability information at NMMU.

7.4 Problems Experienced and Limitations of the Study

Several problems were encountered throughout this research study. The siloed nature of many departments at NMMU meant that finding all the required information proved a difficult task. An example of this being in the development of the NMMU data landscape, where multiple departments were consulted in an attempt to determine who is responsible for the management of what data.

The evaluation of Sustainable BI proved challenging for two different reasons. The first challenge related to the internet speeds at NMMU. The internet speeds at NMMU are very volatile, meaning that some evaluations were hindered by the internet speeds, whereas other evaluations were not hindered by slow internet speeds. The second challenge related to the sourcing of participants for the evaluation, as the potential users of Sustainable BI would be strategic management at NMMU. Therefore strategic management were required to serve as participants in the evaluation of Sustainable BI. The busy nature of strategic management ensured that finding twelve participants for the evaluation proved a difficult task.

The study also experienced several limitations including the scope of the study and the data used by Sustainable BI. The study was focussed entirely on the sustainability information requirements of strategic management at NMMU. The implementation therefore focussed entirely on the reporting, analytical and monitoring layers of the proposed BI framework (Figure 7-3). The data used by Sustainable BI was limited to educational and environmental

data. As the focus of this research is not on the data layer, it was assumed that all data was accurate and clean.

7.5 Future Research

The Sustainable BI prototype can be extended to include additional functionality. The Sustainable BI prototype was limited to environmental and educational data, as this was the only data available to the researcher. By including economic and social data, Sustainable BI can then cover the entire spectrum of sustainability. Research is required to investigate approaches to improve collection and integration of data in the data sources component and the data layer.

The Sustainable BI prototype can also be expanded to include mobile functionality. The current version of Sustainable BI is a web application and can therefore be accessed on mobile devices. Sustainable BI was designed for a standard computer and therefore is not optimised for mobile usage. The speed of Sustainable BI can be enhanced by installing an instance of Tableau server on the NMMU servers. The speed of access could be enhanced significantly if Sustainable BI was hosted locally.

7.6 Summary

This research study has produced three artefacts as part of the DSR methodology, namely:

- The Sustainability Management Model;
- The BI framework to support strategic sustainability information management; and
- The Sustainable BI prototype.

The Sustainability Management Model should be used to make HEIs aware of the different aspects that should be taken into consideration for more effectively managing strategic sustainability information. The model identifies the drivers of sustainability and the constraints that hinder HEIs in effectively managing sustainability.

The BI framework to support effective strategic sustainability information management provides a theoretical foundation for the implementation of a BI solution. The BI framework highlights the different components required for a BI solution to support effective strategic sustainability information management. The components in the framework are the data sources,

the ETL process, the data layer, the reporting layer, the analytical layer, the monitoring layer, the presentation layer and the users. The data sources include financial data sources, environmental data sources, social data sources and educational data sources. The ETL process extracts the data from these siloed data sources, cleans the data and loads it into the data warehouse contained in the data layer. The reporting layer enables the creation of static reports, such as sustainability reports, which are a regulatory requirement. The analytical layer provides forecasting and predictive capabilities that enable strategic management to determine if they are on track to meet long-term sustainability goals. The monitoring layer consists of dashboard and scorecard capabilities that enable management to monitor sustainability efforts. The presentation layer provides a platform through which the users can access the reports and the dashboards. The users include both management at the HEI as well as the public, as sustainability reports have to be publically disclosed.

Sustainable BI is a BI solution that was developed to enable strategic management at NMMU to better manage sustainability efforts. Sustainable BI integrates data from multiple areas of sustainability, and provides a single integrated view of the information. The information is provided to the users through performance dashboards, and provides predictive capabilities to enable management to determine if the institution is on course to meet its long-term goals. The Sustainable BI prototype was evaluated by management at NMMU to determine if it was successful in assisting strategic management effectively manage sustainability information. The results of the evaluation revealed that the Sustainable BI prototype can assist management in improving the management of strategic sustainability information.

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Appendix A. Stars Credit List

ACADEMICS (AC)	ENGAGEMENT (EN)	OPERATIONS (OP)	PLANNING & ADMIN. (PA)
Curriculum ➢ AC 1: Academic Courses *(14)* ➢ AC 2: Learning Outcomes* *(8)* ➢ AC 3: Undergraduate Program**(3)* ➢ AC 4: Graduate Program**(3)* ➢ AC 5: Immersive Experience**(2)* ➢ AC 6: Sustainability Literacy *(4)* Assessment ➢ AC 7: Incentives for Developing Courses *(2)* ➢ AC 8: Campus as a Living Laboratory* *(4)* **Research** ➢ AC 9: Academic Research* *(12)* ➢ AC 10: Support for Research* *(4)* ➢ AC 11: Access to Research* *(2)*	**Campus Engagement** ➢ EN 1: Student Educators Program *(4)* ➢ EN 2: Student Orientation* *(2)* ➢ EN 3: Student Life *(2)* ➢ EN 4: Outreach Materials and Publications *(2)* ➢ EN 5: Outreach Campaign *(4)* ➢ EN 6: Employee Educators Program *(3)* ➢ EN 7: Employee Orientation *(1)* ➢ EN 8: Staff Professional Development *(2)* **Public Engagement** ➢ EN 9: Community Partnerships *(3)* ➢ EN 10: Inter-Campus Collaboration *(2)* ➢ EN 11: Continuing Education* *(5)* ➢ EN 12: Community Service *(5)* ➢ EN 13: Community Stakeholder Engagement *(2)* ➢ EN 14: Participation in Public Policy *(2)* ➢ EN 15: Trademark Licensing* *(2)* ➢ EN 16: Hospital Network* *(1)*	**Air & Climate** ➢ OP 1: Greenhouse Gas Emissions *(10)* ➢ OP 2: Outdoor Air Quality *(1)* **Buildings** ➢ OP 3: Building Operations and Maintenance* *(4)* ➢ OP 4: Building Design and Construction**(3)* ➢ OP 5: Indoor Air Quality *(1)* **Dining Services** ➢ OP 6: Food and Beverage Purchasing* *(4)* ➢ OP 7: Low Impact Dining* *(3)* **Energy** ➢ OP 8: Building Energy Consumption *(6)* ➢ OP 9: Clean and Renewable Energy *(4)* **Grounds** ➢ OP 10: Landscape Management**(2)* ➢ OP 11: Biodiversity**(1-2)* **Purchasing** ➢ OP 12: Electronics Purchasing *(1)* ➢ OP 13: Cleaning Product Purchasing *(1)* ➢ OP 14: Office Paper Purchasing *(1)* ➢ OP 15: Inclusive and Local Purchasing *(1)*	**Coordination, Planning & Governance** ➢ PA 1: Sustainability Coordination *(1)* ➢ PA 2: Sustainability Planning *(4)* ➢ PA 3: Governance *(3)* **Diversity & Affordability** ➢ PA 4: Diversity and Equity Coordination *(2)* ➢ PA 5: Assessing Diversity and Equity *(1)* ➢ PA 6: Support for Underrepresented Groups *(2)* ➢ PA 7: Support for Future Faculty Diversity *(1)* ➢ PA 8: Affordability and Access *(4)* **Health, Wellbeing & Work** ➢ PA 9: Employee Compensation *(3)* ➢ PA 10: Assessing Employee Satisfaction *(1)* ➢ PA 11: Wellness Program *(1)* ➢ PA 12: Workplace Health and Safety *(2)* **Investment** 1. PA 13: Committee on Investor Responsibility* *(2)* 2. PA 14: Sustainable Investment* *(4)*

		➢ OP 16: Life Cycle Cost Analysis *(1)* ➢ OP 17: Guidelines for Business Partners *(1)* **Transportation** ➢ OP 18: Campus Fleet* *(1)* ➢ OP 19: Student Commute Modal Split* *(2)* ➢ OP 20: Employee Commute Modal Split *(2)* ➢ OP 21: Support for Sustainable Transportation *(2)* **Waste** ➢ OP 22: Waste Minimization *(5)* ➢ OP 23: Waste Diversion *(3)* ➢ OP 24: Construction and Demolition Waste Diversion**(1)* ➢ OP 25: Hazardous Waste Management *(1)* **Water** ➢ OP 26: Water Use *(2-6)* ➢ OP 27: Rainwater Management *(2)* ➢ OP 28: Wastewater Management *(1)*	3. PA 15: Investment Disclosure* *(1)* **INNOVATION (IN)** ➢ Innovation *(4)*

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Appendix B. Ethics Approval

Nelson Mandela Metropolitan University

for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Chairperson: Research Ethics Committee (Human)
Tel: +27 (0)41 504-2235

Ref: [H15-SCI-CSS-001 /Approval]

Contact person: Mrs U Spies

8 April 2015

Dr B Scholtz
Faculty: Science
Department: Computing Sciences
09-01-01c
South Campus

Dear Dr Scholtz

A BUSINESS ANALYTICS FRAMEWORK FOR SUPPORTING STRATEGIC SUSTAINABILITY INFORMATION MANAGEMENT IN SOUTH AFRICAN HIGHER EDUCATION INSTITUTIONS

PRP: Dr B Scholtz
PI: Mr R Haupt

Your above-entitled application for ethics approval served at Research Ethics Committee (Human).

We take pleasure in informing you that the application was approved by the Committee.

The ethics clearance reference number is **H15-SCI-CSS-001** and is valid for three years. Please inform the REC-H, via your faculty representative, if any changes (particularly in the methodology) occur during this time. An annual affirmation to the effect that the protocols in use are still those for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline.

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

CB Cilliers

Prof CB Cilliers
Chairperson: Research Ethics Committee (Human)

cc: Department of Research Capacity Development
Faculty Officer: Science

Appendix C. Sustainable BI Heuristic Evaluation

Appendix C.1 Heuristic Evaluation Criteria

Heuristic Evaluation Criteria

Sustainable BI

Consider the following comprehensive set of heuristics/criteria as suggested by Forsell and Johansson (2010) *for evaluation of existing problems in the current design that could negatively affect the usability of the system when identifying problems:*

Number	Heuristic	Description
H1	**Information coding**	Perception of information is directly dependent on the mapping of data elements to visual objects. This should be enhanced by using the correct format and visual objects for representing information.
H2	**Minimal Actions**	The workload of the user should be reduced by minimising the number of actions required to complete a goal or task.
H3	**Flexibility**	Flexibility refers to the number of ways a user can accomplish a given task.
H4	**Orientation and Help**	Functions like support to control levels of detail, redo/undo of actions and representing additional information.
H5	**Spatial organisation**	Spatial organisation refers to the use of space on the dashboard. Visual elements should be placed in a logical order and should be legible.
H6	**Consistency**	The design of dashboards across the entire application should be consistent, by making use of consistent colours and visual elements.
H7	**Recognition rather than recall**	The user should not have to memorise large amounts of information to carry out tasks.
H8	**Prompting**	Prompting refers to all means that help the user to know when several alternative actions are available.
H9	**Remove the extraneous**	Extraneous information that adds no value and only serves as a distraction should be removed from the dashboard.
H10	**Data set reduction**	Features, such as filters, should be provided to enable the user to reduce the data set according to the required task.

Appendix C.2 Heuristic Evaluation Task List

Heuristic Evaluation Task List

Sustainable BI

1 Task 1: Navigating Through Dashboards

1.1 How Many dashboards are provided by Sustainable BI?

Answer: _____

2 Task 2: Extracting Information from Dashboards

2.1 Navigate to the ***Enrolments – ENGINEERING, BUILT ENVIRONMENT AND IT*** dashboard. Which department has the ***highest*** number of enrolments, how many enrolments were there, and what is the applications:admissions:enrolments ratio for that department?

Department: _____**Enrolments:** _____ **Ratio:** _____

2.2 Which gender has the most **enrolments** and what is the **% of total enrolments** for that gender?

Gender: _____ **% of Total Enrolments:** _____

3 Task 3: Interacting with Dashboards

3.1 Navigate to the ***Electricity Usage - NMMU*** dashboard.

3.2 Select ***South Campus*** from the ***Electricity Usage Map*** Graph.

3.3 How many ***Cost Centres*** are there on South Campus?

Answer: _____

3.4 Which cost centre has used the ***most*** electricity and how much electricity did that cost centre use?

Cost Centre: _____ **Usage:** _____

3.5 Select ***South Campus*** from the ***Electricity Usage Map*** Graph to clear the selection.

4 Task 4: Filtering Information on Dashboards

4.1 Navigate to the ***Water Usage – NMMU*** Dashboard.

4.2 Using the filters on the right of the screen:

- Filter the year so that only ***2013*** is selected and click the apply button.
- Filter the month so that only ***December*** is selected and click the apply button.

4.3 Which campus used the ***most*** water in December 2013 and how much water was used?

Campus: _____ **Usage:** _____

4.4 Save the current view by selecting remember my changes drop down list. Name the view YourName_Water.

4.5 Return to the original view by selecting the original view option from the **remember my changes** drop down list.

5 Task 5: Using Drill Down Capabilities

5.1 Navigate to the ***Success Rates - NMMU*** Dashboard.

5.2 Hover the mouse pointer the faculty school name axis title of the ***Success Rates by Faculty*** graph. Click on the plus sign that appears. The graph has now been drilled down into the department level.

5.4 How many departments in the ***Arts faculty*** are above the target success rate?

Answer: _____

5.3 Navigate to and select the ***Computing Sciences department in the Science Faculty***. What is the success rate in the Computing Sciences Department?

Answer: _____

5.4 Hover the mouse pointer the faculty school name axis title of the ***Success Rates by Faculty graph***. Click on the minus sign that appears. The graph has now been drilled up into the faculty level.

5.5 Select the ***Education*** faculty from the ***Success Rates by Faculty Graph***. Has there been an upwards or a downwards trend in success rates in the education faculty between 2000 and 2013?

UPWARDS	DOWNWARDS

Task 6: Using Forecasting Capabilities

6.1 Navigate to the ***Enrolments - NMMU dashboard***.

6.2 Select the ***Business and Economic Sciences faculty*** on the ***Applications vs Admissions vs Enrolments graph***. The enrolments over time dashboard will be filtered based on your selection. What is the estimated enrolments in the ***Business and Economic Sciences faculty in 2016***?

Answer: _____

6.3 Navigate to the ***Electricity Usage Dashboard***.

6.4 Select ***Second Avenue Campus from the Campus Electricity Usage Graph***. The Electricity over Time Dashboard will be filtered based on your selection. What is the estimated electricity usage for ***October 2014***?

Answer: _____

Task 7: Creating a PDF Report

7.1 Select the **Enrolments - INTERNATIONAL** Dashboard.

7.2 Select **USA** from the **International Enrolments Map.**

7.3 Select the **export**  button and select pdf from the drop down menu.

7.4 Change the layout to ***landscape*** and select export

Appendix C.3 Heuristic Evaluation Questionnaire

Heuristic Evaluation
Heuristic Questionnaire
Sustainable BI

*Before completing the tasks, please read through the **Criteria** document in order to understand the heuristics you will be considering during this evaluation. Please complete the **Table 1** which relates to the heuristic problems encountered whilst using Sustainable BI. After completing the tasks using Sustainable BI, please provide additional feedback.*

Heuristics Evaluation Severity of Problems

Please list any problems you encounter in the tasks of using Sustainable BI in the table to follow. Thereafter, rate the severity of the problem using this scale **(Pierotti, 1996)**:

Severity Rating	Description
0	I don't agree that this is a usability problem at all
1	**Cosmetic** problem only: need not be fixed unless extra time is available on project. Will not affect the usability of the system, fix if possible.
2	**Minor** usability problem: users can easily work around the problem, fixing this should be given low priority
3	**Medium** usability problem: users stumble over the problem, but quickly adapt to it, fixing this should be given medium priority
4	**Major** usability problem: important to fix, so should be given high priority. Users have difficulty, but are able to find workarounds, fixing this should be mandatory before the system is launched. If the problem cannot be fixed before launch, ensure that the documentation clearly shows the user a workaround.
5	Usability **catastrophe**: imperative to fix this before product can be released. Users are unable to do their work, fixing this is mandatory.

Problem Severity Rating Table 1: Sustainable BI

Problem Description	Task Number	Severity Rating (0, 1, 2, 3, 4 or 5) 0 = No Problem; 1 = Cosmetic; 2 = Minor; 3 = Medium; 4 = Major; 5 = Catastrophe

Additional feedback: Sustainable BI

1.	Please list two (2) features/aspects you like about Sustainable BI – *best features*
1.1.	
1.2.	

2.	Please list two (2) features/aspects you dislike about Sustainable BI – *worst features*
2.1.	
2.2.	

Appendix D. Sustainable BI Usability Evaluation

Appendix D.1 Sustainable BI Evaluation Task List

Usability Evaluation

Task List

Sustainable BI

6 Task 1: Navigating Through Dashboards

6.1 How Many dashboards are provided by Sustainable BI?

Answer: _____

7 Task 2: Extracting Information from Dashboards

2.1 Navigate to the ***Enrolments – ENGINEERING, BUILT ENVIRONMENT AND IT*** dashboard. Which department has the ***highest*** number of enrolments, how many enrolments were there, and what is the applications:admissions:enrolments ratio for that department?

Department: _____**Enrolments:** _____ **Ratio:** _____

2.2 Which gender has the most **enrolments** and what is the **% of total enrolments** for that gender?

Gender: _____ **% of Total Enrolments:** _____

8 Task 3: Interacting with Dashboards

3.1 Navigate to the ***Electricity Usage - NMMU*** dashboard.

3.2 Select ***South Campus*** from the ***Electricity Usage Map*** Graph.

3.3 How many ***Cost Centres*** are there on South Campus?

Answer: _____

3.4 Which cost centre has used the ***most*** electricity and how much electricity did that cost centre use?

Cost Centre: _____ Usage: _____

3.5 Select ***South Campus*** from the ***Electricity Usage Map*** Graph to clear the selection.

9 Task 4: Filtering Information on Dashboards

4.1 Navigate to the ***Water Usage – NMMU*** Dashboard.

4.2 Using the filters on the right of the screen:

- Filter the year so that only ***2013*** is selected and click the apply button.
- Filter the month so that only ***December*** is selected and click the apply button.

4.3 Which campus used the ***most*** water in December 2013 and how much water was used?

Campus: _____ Usage: _____

4.4 Save the current view by selecting remember my changes drop down list. Name the view YourName_Water.

4.5 Return to the original view by selecting the original view option from the **remember my changes** drop down list.

10 Task 5: Using Drill Down Capabilities

5.1 Navigate to the ***Success Rates - NMMU*** Dashboard.

5.2 Hover the mouse pointer the faculty school name axis title of the ***Success Rates by Faculty*** graph. Click on the plus sign that appears. The graph has now been drilled down into the department level.

5.4 How many departments in the ***Arts faculty*** are above the target success rate?

Answer: _____

5.3 Navigate to and select the ***Computing Sciences department in the Science Faculty***. What is the success rate in the Computing Sciences Department?

Answer: _____

5.4 Hover the mouse pointer the faculty school name axis title of the ***Success Rates by Faculty graph***. Click on the minus sign that appears. The graph has now been drilled up into the faculty level.

5.5

5.5 Select the ***Education*** faculty from the ***Success Rates by Faculty Graph***. Has there been an upwards or a downwards trend in success rates in the education faculty between 2000 and 2013?

UPWARDS	DOWNWARDS

Task 6: Using Forecasting Capabilities

6.1 Navigate to the ***Enrolments - NMMU dashboard***.

6.2 Select the ***Business and Economic Sciences faculty*** on the ***Applications vs Admissions vs Enrolments graph***. The enrolments over time dashboard will be filtered based on your selection. What is the estimated enrolments in the ***Business and Economic Sciences faculty in 2016***?

Answer: _____

6.3 Navigate to the ***Electricity Usage Dashboard***.

6.4 Select ***Second Avenue Campus from the Campus Electricity Usage Graph***. The Electricity over Time Dashboard will be filtered based on your selection. What is the estimated electricity usage for ***October 2014***?

Answer: _____

Task 7: Creating a PDF Report

7.1 Select the **Enrolments - INTERNATIONAL** Dashboard.

7.2 Select **USA** from the **International Enrolments Map.**

7.3 Select the **export** button and select pdf from the drop down menu.

7.4 Change the layout to ***landscape*** and select export

Appendix D.2 Post-Test Questionnaire for Sustainable BI Usability Evaluation

Usability Evaluation Questionnaire

Sustainable BI

Nelson Mandela Metropolitan University

for tomorrow

1.	BIOGRAPHICAL INFOMRATION					
1.1	Age	18-30	31-40	41-50	>50	
1.2	Gender	Male	Female			
1.3	Education	Undergrad Degree	Honours Degree	Masters Degree	PHD	Other
1.4	Numbers of years' experience with computers	<1	1-5	6-10	>10	
1.5	Number of years' experience with BI software	<1	2-3	4-5	>5	
1.6	How frequently do you use BI tools	Daily	Weekly	Monthly	Yearly	Never

2. VISIBILITY

2.1	The information is displayed in an uncluttered and well-structured manner.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
2.2	Instructions are visible and self-explanatory.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
2.3	Navigation options (links, shortcuts, home, back, forward, etc.) are clearly displayed.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
2.4	The application communicates the system status at all times.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

3. FLEXIBILITY

3.1	I felt in control of the application.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
3.2	The application is customisable for individual or collaborative usage.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

4. LEARNABILITY

4.1	The application requires limited memory load	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
4.2	The application promotes learnability to make it accessible for infrequent usage	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
4.2	The terminology used by the application is familiar	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

5. ERROR CONTROL AND HELP

5.1	The application makes provision for error prevention and recovery.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
5.2	The application provides user support	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

6.	OPERABILITY							
6.1	Data is accessible on different levels of aggregation.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.2	The system displays a hierarchical map to determine data granularity level.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.3	Filters applied to data are highly visible at all times	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.4	The data is up-to-date or else the user is notified that the data is out-dated	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.5	The application allows knowledge sharing and exporting data	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.6	I have the option to save data views on the application.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.7	There is an information visualisation functionality (comparison charts, graphs to reveal trends, etc.) to assist in decision-making	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
6.8	The application behaviour is consistent.	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

7.	EFFECTIVENESS							
7.1	I could complete all the tasks successfully using the system	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
7.2	I could effectively complete tasks and scenarios using the system	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
8.	EFFECIENCY							
8.1	The application provides a rapid response rate	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
8.2	I was able to complete the tasks and scenarios quickly using the system	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
8.3	I was able to efficiently complete the tasks and scenarios using the system	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

9. BENEFITS OF BI

The BI application can help me realise the following benefits

9.1	The system provides more and better information	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
9.2	The system provides me with better decision-making capabilities	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
9.3	The system provides improved support for managing strategic goals	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
9.4	The system can help improve organisational performance	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**
9.5	The system provides me with integrated information	**Strongly Disagree**	1	2	3	4	5	**Strongly Agree**

10. POSITIVE FEATURES OF SUSTAINABLE BI

Please list any positive features of Sustainable BI

_____

_____

_____

_____

_____

_____

11. NEGATIVE FEATURES OF SUSTAINABLE BI

Please list any negative features of Sustainable BI

_____

_____

_____

_____

_____

_____

Appendix E. SAICSIT Paper