AN ENTERPRISE ARCHITECTURE FOR ENVIRONMENTAL INFORMATION MANAGEMENT AND REPORTING

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An Enterprise Architecture for Environmental Information Management and Reporting

By

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Declaration

I, Anthea Van der Hoogen (s207026467), hereby declare that the dissertation for the degree Magister Commercii is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

_____

Anthea Van der Hoogen

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Summary

Organisations globally are communicating their environmental sustainability impact to stakeholders by means of the widely used sustainability report. A key benefit of environmental sustainability reporting is that organisations can gain a positive reputation when these reports are presented to stakeholders. Organisations in South Africa are faced with many challenges regarding managing sustainability information and producing an environmental sustainability report. Two of the primary challenges are the many diverse standards for sustainability reporting and data quality issues.

Information Technology (IT) can be used to support and improve the process of sustainability reporting but it is important to align the environmental sustainability strategies with the strategies of business and also with the IT strategy to avoid silos of information and reporting. Enterprise Architecture (EA) can be used to solve alignment problems since it supports business-IT alignment. EA is defined by the International Standards Organisation (ISO) as "*The fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution*". It can be argued, therefore, that EA can be used to support environmental sustainability information management and the reporting process by means of its support of improved business-IT alignment and ultimately integrated systems.

The main objective of this study is to investigate how EA can be used to support environmental information management (EIM) and reporting. A survey study of thirty one prominent South African organisations was undertaken in order to investigate the status of their EA adoption and environmental reporting and EIM processes. An EA for EIM Toolkit and a set of guidelines are proposed which can provide support for EIM through the use of EA. These guidelines were proposed based on best-practice for each of the three process levels of an organisation, namely, the strategic level, the operational level and the technological level. The toolkit and guidelines were derived from theory and the results of the industry survey were then validated by an in-depth analysis of a case study consisting of multiple cases with key employees of seven South African organisations which have proved to be successful at EA and EIM and reporting. The results of the case study show that the EA for EIM Toolkit and related guidelines can assist organisations to align their environmental sustainability strategies with their organisational and IT strategies.

Keywords: Sustainability reporting, environmental reporting, environmental sustainability strategy, environmental information management, enterprise architecture.

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List of Abbreviations

AA1000APS	AA1000 AccountAbility Principles Standard
AA1000AS	AA1000 Assurance Standard
ABB	Architecture Building Blocks
ADM	Architecture Development Method
AF	Architectural Framework
APIs	Application Programming Interfaces
ARIS	Architecture of Integrated Information Systems
ARM	Application Reference Model
ASP	Application Service Provider
BI	Business Intelligence
BPM	Business Process Management
BPMN	Business Process Modelling Notation
BRM	Business Reference Model
CDP	Carbon Disclosure Project
CERES	Coalition for Environmentally Responsible Economies
CFO	Chief Financial Officer
CIO	Chief Information Officer
CLIME	Climate and Lake Impacts in Europe
CMMI	Capability Maturity Model Integration
COP17	Conference of Parties
CRF	Connected Reporting Framework
CRM	Consolidated Reference Model
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DRM	Data Reference Model
DSS	Decision Support System
E2SP	Environmental Enterprise Service Provider
EA	Enterprise Architecture
EDM	Enterprise Data Model
EIM	Environmental Information Management
EITI	Extractive Industries Transparency Initiative
EM	Enterprise Modelling
EMAS	Eco-Management and Audit Scheme
EMIS	Environmental Management Information System
EMS	Environmental Management System
EN	Environmental
ERP	Enterprise Resource Planning
ESG	Environmental, Social and Corporate Governance
FEAF	Federal Enterprise Architecture Framework
GHG	Greenhouse Gas
GIT	Global Information Technology

GRI	Global Reporting Initiative
IAASB	International Auditing and Assurance Standards Board
ICT	Information Communication Technology
IDEF	Integration DEFinition
IFEAD	Institute For Enterprise Architecture Development
IRM	Infrastructure Reference Model
IS	Information Systems
ISAE	International Standard on Assurance Engagements
ISO	International Organisation for Standardisation
IT	Information Technology
JSE	Johannesburg Stock Exchange
KPI	Key Performance Indicator
LCA	Life-cycle assessment
MODAF	Ministry of Defense Architecture Framework
MS	Microsoft
NGO	Non-Government Organisation
NMMU	Nelson Mandela Metropolitan University
OEAF	Oracle EA Framework
OECD	Organisation for Economic Co-operation and Development
PAS	Publicly Available Specification
PFMA	Public Finance Management Act
PRM	Performance Reference Model
RC	Ranking Category
RO	Research Objective
ROI	Return on Investment
RQ	Research Question
SAAS	Software as a Service
SD	Standard Deviation
SOA	Service Oriented Architecture
SRI	Socially Responsible Investment
SRI Index	Socially Responsible Investment Index
SRM	Security Reference Model
STORM	Sustainable Online Reporting Model
TAFIM	Technical Architecture Framework for Information Management
TBL	Triple Bottom Line
TOGAF	The Open Group Architectural Framework
UML	Unified Modelling Language
UN	United Nation
UNEP	United Nations Environment Programme
UNPRI	UN Principles for Responsible Investment
US	United States

Chapter 1 Introduction

1.1 Background

Transparency of sustainability impact has become a critical objective for modern organisations in order to maintain their competitive advantage and environmental sustainability in particular is becoming part of the so called corporate agenda (Weybrecht, 2010). Sustainability is seen as the centre-piece of an organisation and it is strongly advised that sustainability issues should be included in the overall strategy of the organisation (Magoulas *et al.*, 2012; SAICA, 2009). This will benefit the organisation as it will market the organisation to the public and stakeholders as being a responsible corporate citizen (SAICA, 2009). In South Africa, corporate citizenship entails that organisations should be sustainable and therefore they should be able to support and meet the needs of future generations.

Internationally, organisations are making a priority of reducing their environmental impact (UNEP *et al.*, 2010). The South African government committed to reducing its carbon footprint during the 17th Conference of Parties (COP17) international event (DEA, 2011). South African companies producing Global Reporting Initiative (GRI) reports, have shown an increase in taking action in reducing their carbon footprint by disclosing such information (Rea, 2012). South African organisations by law have to "apply or explain" the King III report which places great emphasis on sustainability (SAICA, 2009). Sustainability reporting includes three areas also known as the Triple Bottom Line (TBL) namely: economic, environmental and social (Elkington, 1994). A sustainability report should therefore include these three areas (GRI, 2013a). Environmental sustainability reporting is thus a subset of sustainability reporting.

The long-term survival and profitability of many international organisations are becoming more dependent on sustainability reporting systems and proper records management (Chachage *et al.*, 2006). Record management is also an important feature of environmental information systems as most of the data that are being recorded constantly has to be managed simultaneously. In order for an organisation to address its environmental performance, it has to address its environmental sustainability strategies, also known as "Green" initiatives (Esty and Simmons, 2011; Speshock, 2010; Weybrecht, 2010). Many environmental sustainability strategies have been adopted by organisations in order to better manage their impact on the environmental (Speshock, 2010).

Sustainability should be seen as an integrated aspect of an organisation, and thus organisations should produce an integrated sustainability report (SAICA, 2009; Weybrecht, 2010). One of the challenges of environmental sustainability and Environmental Information Management (EIM) is that environmental sustainability information is not easily retrieved, stored and presented (Ernst and Young LLP and Boston College, 2013; Purvis *et al.*, 2000; Solsbach *et al.*, 2011). Decision-making, therefore, concerning sustainability issues becomes increasingly difficult for managers as such information is not easily accessible. Better management of information by organisations can lead to better reporting practices which can be used for decision-making. With improved information management and decision-making, organisations will be able to achieve the main objective of sustainability reporting, which is to produce an integrated report.

It is therefore necessary to investigate the methods, tools, technologies and processes that can improve the process of EIM and reporting. First it is important to integrate the environmental sustainability issues regarding information management within the overall organisational strategy. If organisations want to achieve their environmental sustainability objectives, they must align these objectives with their organisational objectives (A4S, 2009; Ernst and Young and GreenBiz Group, 2012; GRI, 2013c; KPMG, 2008; Speshock, 2010). The Global Information Technology (GIT) report shows that South Africa is doing quite well in terms of availability of latest technologies since it is ranked 39th out of 142 economies for having the latest technologies available (Dutta and Bilbao-Osorio, 2012). This report however also shows that South Africa is a bit further behind in terms of *accessibility of digital content*, which shows a ranking of 83rd for South Africa out of 142 economies. It could be deduced therefore that if the available technologies were used more effectively it could make the process of accessing digital content easier.

Organisations must therefore use their available technologies and align their Information Technology (IT) strategies with their organisational strategies, also known as business-IT alignment (Pereira and Sousa, 2005). Sixty percent of the Chief Information Officers (CIOs) who took part in the 2012 State of the CIO research, reported by the CIO magazine, stated that business-IT alignment takes the greater part of their time and focus (ITWorld, 2013). A number of studies propose that the use of an Enterprise Architecture (EA) can assist the task of business-IT alignment (Egham, 2010; Iyamu, 2011; Plazaola *et al.*, 2008; Silvius, Waal and Smit, 2009).

The International Organisation for Standardisation (ISO) defines EA as "*The fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution*" (ISO/IEC/IEEE, 2011, p. 2). An EA consists of four main components namely, business architecture, data architecture also known as Information Architecture and will further be referred to as Information Architecture, Technology Architecture and Application Architecture (The Open Group, 2009a).

It is necessary to investigate the environmental information requirements of an organisation which is needed to produce an integrated sustainability report (Purvis *et al.*, 2000; GRI, 2013c; SAICA, 2011; Stapleton *et al.*, 2001). Stakeholders are demanding greater relevance of sustainability and environmental reporting (Section 1.1.1) and force organisations to report on their environmental impact (GRI, 2013a; King and Lessidrenska, 2009). Therefore organisations have to understand how to manage and incorporate their environmental sustainability strategies and align these to their organisational strategies. This can lead to better environmental reporting and sustainability reporting practices.

EA is extremely important in organisations and the main purpose of EA is to improve the applicability, accessibility and usefulness of information (Section 1.1.2). EA provides the opportunity to address both the information requirements and the tools and technologies that can be used to address the environmental sustainability and EIM requirements of organisations.

1.1.1 Environmental Reporting and Sustainability Reporting

Research and development are increasing gradually in the field of environmental sustainability in South Africa (GRI, 2013c). A study was done by GRI (2013b) to investigate the adoption of integrated sustainability reporting with the focus on South African organisations. This study illustrated that since 2010 only 18% of a total of 756 reports declared by organisations were integrated reports which included both the annual financial report and sustainability reporting information. The majority of the organisations which produced sustainability reports were large organisations from the private sector. Globally it is shown that 74% of private companies produce an integrated sustainability report (GRI, 2013c). This indicates that more South African organisations from different sectors should pay more attention to sustainable development and strategies.

Sustainable development is development that *"meets the needs of the present without compromising the ability of future generations to meet their own need*" (World Commission on Environment and Development, 1987, p. 16). The purpose of sustainability is to disclose information about an organisation's performance in terms of sustainable development to internal and external stakeholders (GRI, 2013a). The stakeholders could range from employees, customers, suppliers, to financial investors and the broader public.

The public concern about environmental factors has increased over the past two decades and it has been legislated that the public have the right to environmental information (Howman and Nepfumbada, 2000; SAICA, 2009). Therefore, it is important to investigate how the management of environmental information takes place and especially how such information is reported to the public.

Environmental information can be managed by using Environmental Management Systems (EMS) and Environmental Management Information Systems (EMIS) (ISO, 2004; ISO, 2009; El-Gayar and Fritz, 2006). These terms are often used interchangeably but can become confusing and will be defined later. Information management for sustainability reports is a process which includes recording, extracting and compiling information related to sustainability for reporting purposes (Chachage *et al.*, 2006). These records, kept by an organisation about sustainability information are said to be evidence of the organisation's participating in sustainable practices. The records are also useful for environmental and EMS audits. Records on environmental information are usually kept in record management systems within an organisation.

An EMS is used to establish an environmental policy and for the management of all environmental aspects of an organisation (ISO, 2004; ISO, 2009). An EMS is also referred to as a systematic approach that should be followed in accordance with an internationally acceptable certifiable standard (Stapleton *et al.*, 2001). An example of an internationally acceptable standard for an EMS is the ISO 14001(ISO, 2009). The key elements of an EMS which are in accordance with the requirements of ISO 14001 are: environmental policy, planning, implementation, corrective action and management review. These elements are used by organisations for continual improvement of their environmental processes and are reported in sustainability reports.

Purvis *et al.* (1999) reported that locating and accessing environmental data is only one of the problems regarding the management of environmental information. This is confirmed in a number of studies (Ernst & Young LLP and Boston College, 2013; Solsbach *et al.*, 2011).

Information processing and analysis are also problems encountered and must be supported by an effective EMIS. EMIS is defined by El-gayar and Fritz (2006, p. 756) as '*organizational-technical systems for systematically obtaining, processing, and making available relevant environmental information available in companies*'.

Information management for sustainability reports is a process which includes recording, extracting and compiling sustainability-related information for reporting purposes (Chachage *et al.*, 2006). The records that are kept in an organisation about sustainability information are said to be evidence of the organisation participating in sustainable practices. The records are also useful for environmental and EMS audits. The records on environmental information are usually kept on record management systems within an organisation.

It is important to be able to address the need for a systematic approach in an organisation, firstly to address how environmental sustainability information strategies can be incorporated into the organisational strategies. Pereira (2005) demonstrates that an organisation must address its EA to be able to achieve alignment between business and IT strategies.

1.1.2 Enterprise Architecture

EA was first developed and used by John Zachman during 1987 (Zachman, 1987), however it was restricted to the field of information systems. Since 1987, a steady increase in interest in EA is presently evident (Magoulas *et al.*, 2012). The concept has evolved to include the enterprise as a whole, and is now being interpreted by academia, the public and private sectors. An EA represents how an organisation plans to incorporate changes. It should include the present and future organisational "*objectives, goals, visions, strategies, informational entities, business processes, people, organization structures, application systems, technological infrastructures, and so on*" (Pereira, 2005, p. 1344). EA has become the focus in many organisations as EA is one of the main drivers of a successful organisation (Magoulas *et al.*, 2012). EA is defined as guides or frameworks that can assist organisations to apply a plan in their organisations. EA can also be referred to as a blueprint which outlines a set of guidelines of an organisation (Resmini and Rosati, 2004).

It has been reported in some studies that organisations in South Africa still do not use EA due to the skills shortage in the field of EA and as the budget for EA receives a low priority (Evans, 2010; Van der Merwe *et al.*, 2010; Schekkerman, 2005). The report by Schekkerman (2005) included many questions regarding the trends in EA identified by several organisations (Figure 1-1).

The EA activity ranking for organisations in South Africa was 1.85% and 1.50% in the years 2004 and 2005 respectively and these percentages are a representation of the total number of organisations registered on the website of the Institute For Enterprise Architecture Development (IFEAD). This is an indication that the development and trends of architectural activities were not easily adopted by organisations in South Africa. However a recent study by Josey (2013) shows that South Africa is ranked seventh globally for the number of The Open Group Architecture Framework (TOGAF) certifications. Even though TOGAF is not the only EA framework adopted in South Africa, the TOGAF certification results reported by Josey (2013) was the only recent report of EA activity in South Africa identified at the time of this study. These TOGAF certification results can give some indication that there is a trend of EA adoption in South Africa.

2005	Country	EA Activity	%	2004	Country	EA Activity	%
1.	United States of America		45.27%	1.	United States of America		45.05%
2.	United Kingdom		6.50%	2.	Netherlands		6.16%
3.	Canada		6.24%	3.	United Kingdom		5.25%
4.	Netherlands		5.54%	4.	Canada		4.78%
5.	Australia		4.66%	5.	Australia		4.50%
6.	India		2.60%	6.	South Korea		2.97%
7.	Germany		2.55%	7.	Japan		2.68%
8.	South Korea		1.78%	8.	Germany		2.42%
9.	France		1.64%	9.	Iran		2.13%
10.	South Africa		1.50%	10.	India		1.99%
11.	Japan		1.48%	11.	South Africa		1.85%
12.	Sweden		1.25%	12.	France		1.79%
13.	Iran		1.24%	13.	Sweden		1.20%
14.	China		1.07%	14.	Belgium		1.16%
15.	Switserland		0.99%	15.	China		1.01%
16.	Belgium		0.90%	16.	Finland		0.89%
17.	Singapore		0.80%	17.	Switserland		0.71%
18.	Italy		0.75%	18.	Spain		0.70%
19.	Brazil		0.70%	19.	Italy		0.66%
20.	Spain © Copyright, IFEAD 2005		0.69%	20.	Singapore		0.63%

Figure 1-1: EA Activity Ranking (Schekkerman, 2005)

The Josey (2013) study is very relevant since many organisations are using EAs today and research shows that by 2015 even more organisations will use EAs to help align their strategies to their processes (Section 1.2). The problem identified in this study further illustrates that legacy information systems do not make provision for supporting EIM and reporting, nor do they consider incorporating their environmental sustainability strategies in all their processes (Section 1.3). Unless organisations change their way of operating they will be faced with overwhelming demands from a compliance view and from their stakeholders who require such reports. A research statement was identified to direct this study (Section 1.4), which led to identifying the research objectives (Section 1.5) which will be used to answer the research questions (Section 1.6) for this study. A suitable research methodology was selected for this study (Section 1.7). The research statement helps to define this study, yet certain constraints were identified (Section 1.8). The overall chapter structure illustrates the research objectives, research questions and chapter deliverables for each chapter in this study (Section 1.9).

1.2 Relevance of this Study

Gartner (2010) predicts that by the year 2015 more than 95% of organisations will adopt an EA. A sustainable organisation has the ability to balance social, environmental and economic concerns and thus to present these concerns or success factors in a format acceptable to stakeholders and to the broader public. This is known as a sustainability report (GRI, 2011a; Weybrecht, 2010). Interest and concern concerning environmental sustainability reporting have increased (Rea, 2012). Studies have shown the importance of addressing environmental strategy in an organisation's strategy (Speshock, 2010; Weybrecht, 2010).

Aldea *et al.* (2013) report that there is a lack of models which provide a good framework and or a guideline for strategic support. It is therefore important to view what organisations are doing in terms of their strategies to address EIM (Speshock, 2010). It is proposed that the EA which represents how the organisation is managed in terms of its strategies, information or data, technology and applications has to be addressed (Sessions, 2007; Taleb and Cherkaoui, 2012; Wang, Zhou and Jiang, 2008). When introducing an EA in an organisation, it is critical to investigate studies of EA implementations in other organisations and is therefore required to review best-practice of previous successful implementations (Resmini and Rosati, 2004).

1.3 Problem Statement

Existing information systems do not make provision for the environmental processes of an organisation (Ernst and Young and GreenBiz Group, 2012; Molnár and Szabó, 2011). Concern however about the environment, is growing. This is because there is more emphasis on environmental concerns but this can almost be regarded as a new or separate process in organisations.

Cislaghi *et al.* (2006) report that environmental information is specialised and only key users are responsible for accessing and updating the required environmental information and management functions of environmental information. South African organisations lack developmental and strategic focus on EA activities (Schekkerman, 2005). There is a need to adapt existing EA to support environmental information.

The research problem investigated in this study is as follows:

The extent to which existing Enterprise Architecture supports Environmental Information Management and Reporting is not known.

1.4 Dissertation Statement

An EA contains components that are able to assist organisations with integrating their strategies, plans and IT components. An EA will be investigated to establish how it can be used to support organisations in managing their environmental information and reporting. This proposed EA will provide a set of guidelines to organisations which should therefore be able to assist organisations in aligning their organisational, IT and environmental sustainability strategies.

The dissertation statement that focuses this research is:

An Enterprise Architecture (EA) can be used to support effective Environmental Information Management (EIM) and reporting.

1.5 Research Objectives

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

RO_M: To investigate and propose the use of an Enterprise Architecture for EIM (Toolkit and guidelines) for supporting environmental sustainability strategies and Environmental Information Management and reporting in organisations.

The following six secondary research objectives were identified in order to achieve the main objective:

RO1: To investigate and describe the status of environmental and sustainability reporting in organisations relating to:

- The objectives, benefits and challenges of sustainability reporting for organisations;
- The standards, tools and technologies implemented by organisations for environmental and sustainability reporting; and
- The requirements for Environmental Information Management and environmental reporting.

RO2: To identify the objectives, benefits and challenges of Enterprise Architecture adoption in organisations.

RO3: To identify the frameworks, tools and technologies adopted for Enterprise Architecture in organisations.

RO4: To identify and apply a suitable research methodology for this study.

RO5: To investigate Enterprise Architecture and environmental sustainability reporting practices in South African organisations.

RO6: To identify the practices of successful South African organisations with regards to the use of Enterprise Architecture for supporting environmental sustainability reporting.

In order to address the research objectives of this study, a number of research questions need to be investigated. The following sections will identify the research questions for this study.

1.6 Research Questions

The main research question (RQ_M) for this study is: "*How can Enterprise Architecture be used to support environmental sustainability strategies and Environmental Information Management and reporting in organisations?*"

In order to answer this question, the following secondary research questions were identified:

RQ1: What is the status of environmental and sustainability reporting in organisations relating to:

- What are the strategies for sustainability reporting (objectives, benefits and challenges) for organisations?
- What standards, tools and technologies are implemented by organisations for environmental and sustainability reporting?
- What are the requirements for Environmental Information Management and environmental reporting?

RQ2: What are the objectives, benefits and challenges of Enterprise Architecture adoption in organisations?

RQ3: What frameworks, tools and technologies are adopted for Enterprise Architecture in organisations?

RQ4: What is a suitable research methodology for this study?

RQ5: What are South African organisations doing with regard to Enterprise Architecture and environmental sustainability reporting?

RQ6: How are successful South African organisations using Enterprise Architecture to support environmental sustainability reporting and Environmental Information Management?

1.7 Research Methodology

The research philosophy that will be adopted by this research is positivism and interpretivism, which allows for research to be conducted on humans (Saunders *et al.*, 2009). An advantage of the positivist philosophy is that the data that will be collected will be based on the findings of surveys and case studies and thus does not rely on the opinions of the researcher. An advantage of the interpretivist philosophy is that it provides the opportunity to investigate data in detail through the use of interviews and especially by the case study strategy chosen for this research (Thomas, 2011).

Both the inductive and deductive research approach will be used for the purpose of this research. The inductive approach is referred to as theory building and the deductive approach is also known as theory testing or what would be described as scientific writing (Saunders *et al.*, 2009). The inductive approach will allow for the establishment of a proposed theoretical model for this study. The deductive approach includes testing a theory or a statement and this approach will help to establish the answers to the posed research questions. A literature review was needed as it helps researchers to familiarise themselves with work that has been done about their topics and provides the researcher with the capacity to construct a research methodology (Erwee, 1994).

To address the main research objective of an EA for EIM, it is necessary first to explore its current status in organisations. A survey and case study strategy will be used in this research study (Saunders *et al.*, 2009). The survey strategy will help in the collection of the primary data.

Thomas (2011) refers to the case study strategy as research which focuses on a single 'thing'. This 'thing' should be viewed in detail and no attempt should be made to generalise from it. The 'thing' could refer to as a person, group or event. The case study research method can be used as a qualitative tool that intends to provide descriptions about events or small groups of people or objects (MacNealy, 1999).

The multiple case study selection for this research study will be based on organisations that follow best-practice guidelines for their EA and EIM and reporting practices. The organisations for the case study will be selected based on their score in the survey study. Interviews will be done to verify the proposed EA for EIM and the proposed best-practice guidelines.

The research methods employed in this study are both qualitative and quantitative (Creswell *et al.*, 2007). The relevant research instruments for this research are questionnaires and interviews where structured, semi-structured and unstructured interviews will be done in person and via telephone calls (Gill *et al.*, 2008). Primary and secondary data will be collected for this research not only to answer the research questions but also for the purpose of achieving the research objectives. Once the data has been collected, it will be analysed by using appropriate methods. The data in this research will be analysed using four components of data analysis namely: data collection, data display, data reduction and drawing conclusions (Miles and Huberman, 1994).

1.8 Scope and Constraints

This research will focus primarily on investigating EA for EIM. This study refers to the EA for EIM as a Toolkit. A set of best-practice guidelines for EA for EIM Toolkit is proposed. The proposed EA for EIM Toolkit is based on TOGAF EA design.

The validation of the proposed EA for EIM Toolkit will take place using a smaller sample of organisations selected from the large sample at organisations that initially took part in the survey study for this research. This research will also focus on illustrating how to align the strategies of the organisations to the IT strategies and to the environmental sustainability strategies as well as present examples of tools and technologies to achieve this. The small sample for this study was limited to medium and large South African organisations; and therefore statistical tests for the results were also limited.

1.9 Chapter Structure

The proposed chapter outline is shown in this section. Research strategies and chapter deliverables are also provided (Table 1-1). The overall outline of the chapter structure is proposed (Figure 1-2). The research topic was introduced in Chapter 1.

Chapter 2 investigates the environmental sustainability strategies of organisations, which will lead to the investigation of the objectives, challenges, standards, and tools and technologies used to create environmental sustainability reports. This chapter will also focus on the environmental information needs. Chapter 2 will also demonstrate the alignment between the environmental sustainability strategies and organisational strategies. EA will be investigated in Chapter 3 in order to establish the use of an EA that can support the environmental sustainability strategy. The research design will include the methods, methodologies, philosophy and the research strategies for this research in Chapter 4. The theoretical model will present the elements for the EA for EIM Toolkit in this chapter.

The validation of the proposed EA for EIM Toolkit will be updated in Chapter 5 based on the results from the survey study. Some organisations will verify the best-practice guidelines for the toolkit which are reported on in Chapter 6 and present the findings from the interviews during the case studies. Therefore the EA for EIM Toolkit will be updated to reflect any new findings which validated the toolkit in this chapter. Chapter 7 will illustrate what can be investigated in the future as part of this research topic. Conclusions and recommendations will be made based on the findings in the survey study, case study and in literature.

Table 1-1: Chapters Addressing Research Questions and Objectives

Research Objectives		Research Questions		Research Strategies and Data Collection Methods	Chapters	Chapter Deliverable
RO1	To investigate and describe the objectives, benefits and challenges of sustainability reporting for organisations.	**RQ1**	What are the strategies for sustainability reporting (objectives, benefits and challenges) for organisations?	*Literature Study*	Chapter2	Status of environmental and sustainability reporting in organisations.
	To investigate and describe the standards, tools and technologies implemented by organisations for environmental and sustainability reporting.		What standards, tools and technologies are implemented by organisations for environmental and sustainability reporting?			
	To investigate and describe the requirements for Environmental Information Management and environmental reporting.		What are the requirements for Environmental Information Management and environmental reporting?			
RO2	To identify the objectives, benefits and challenges of Enterprise Architecture adoption in organisations.	**RQ2**	What are the objectives, benefits and challenges of Enterprise Architecture adoption in organisations?	*Literature Study*	Chapter3	The objectives, benefits and challenges of enterprise architecture adoption in organisation.
RO3	To identify the frameworks, tools and technologies adopted for Enterprise Architecture in organisations.	**RQ3**	What are the frameworks, tools and technologies adopted for Enterprise Architecture in organisations?			The frameworks, tools and technologies adopted for enterprise architecture in organisations.
						Proposed EA for EIM Toolkit (Version 1).
RO4	To identify and apply a suitable research methodology for this study.	**RQ4**	What is a suitable research methodology for this study?	*Research Design Process*	Chapter4	Research process and design
RO5	To investigate Enterprise Architecture and environmental sustainability reporting practices in South African organisations.	**RQ5**	What are South African organisations doing with regard to Enterprise Architecture and environmental sustainability reporting?	*Survey Study*: To verify the research objectives (RO1-RO3) and to answer the research questions (RQ1-RQ3).	Chapter5	Survey study results. Proposed EA for EIM Toolkit (Version 2). List of selected organisations for case study.
RO6	To identify the practices of successful South African organisations with regards the use of Enterprise Architecture for supporting environmental sustainability reporting.	**RQ6**	How are successful South African organisations using Enterprise Architecture to support environmental sustainability reporting and Environmental Information Management?	*Case Study:* Interviews with organisations to validate the proposed guidelines for EA for EIM Toolkit based on their best-practice.	Chapter6	Proposed guidelines and EA for EIM Toolkit (Version 3).

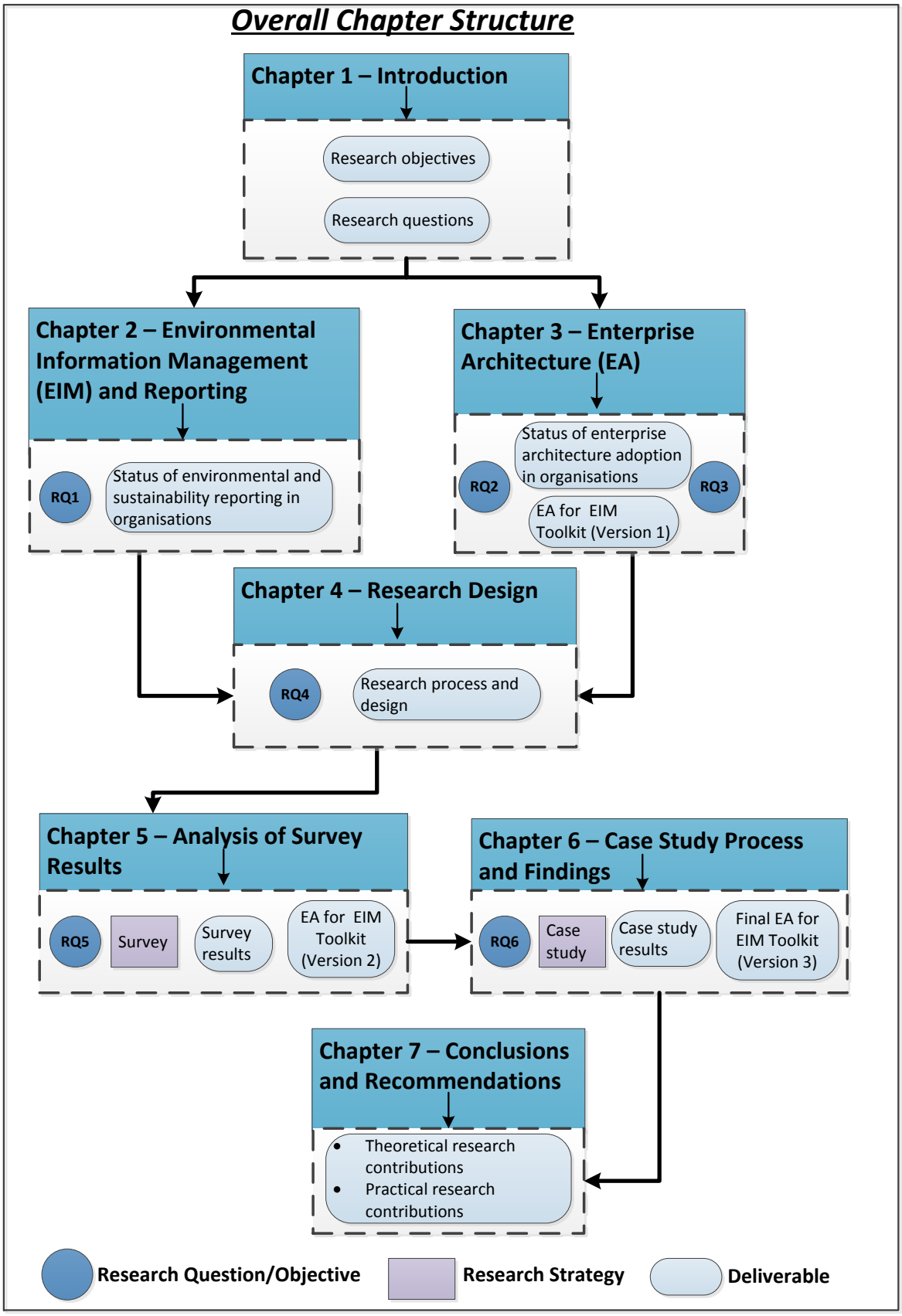


Figure 1-2: Overall Chapter Structure

Chapter 2 Environmental Information Management and Reporting

2.1 Introduction

The previous chapter outlined the context for this research where the research objectives were established. Energy sources and global warming effects have increased the demand of "*customer pressures, and the need to reduce carbon footprints and emissions*" and are forcing organisations to have sustainability strategies in place (Speshock, 2010, p. 3). South African organisations will have to address their sustainability strategies since according to the King III report "*all companies* are *required to produce an integrated report*" which includes both sustainability and financial information (SAICA, 2009, p. 23).

Speshock (2010) reports that to overcome the challenges of environmental sustainability reporting, organisations should align their sustainability strategy with other organisational strategies and utilise the appropriate resources. Murugesan and Gangadharan (2012) agree that to achieve these sustainability strategies several resources of an organisation are required and one of these resources is the Information Technology (IT) department. The IT resource is also known to form part of the business-IT strategy within organisations in order to promote the "*organisation's profitability, productivity, efficiency, competitiveness and compliance, and positively affect many other strategic goals*" (Speshock, 2010, p. 28). The role of the IT department is also to produce integrated Information Systems (IS) that will overcome information silos within organisations. It can therefore be stated that in order to achieve optimal environmental sustainability benefits the organisational strategies, environmental sustainability strategies and IT strategies should be aligned.

In this chapter the first research question (RQ1) will be addressed, namely, *What is the status of environmental and sustainability reporting in organisations?*. This research question will be answered by investigating the following elements of the status of sustainability reporting, namely:

- The strategies for sustainability reporting (objectives, benefits and challenges) of organisations;
- The standards, tools and technologies implemented by organisations for environmental and sustainability reporting; and
- The requirements for environmental information management (EIM) and environmental reporting.

The chapter structure (Figure 2-1) illustrates the different sections and sub-sections in this chapter. In order to answer this research question, environmental sustainability reporting strategies and approaches are investigated and will be based on the field of sustainability reporting in general as well as the environmental sustainability reporting objectives (Section 2.2). A number of environmental sustainability benefits can be achieved when organisations address their environmental sustainability strategies and one of these benefits includes strategic alignment (Section 2.3).

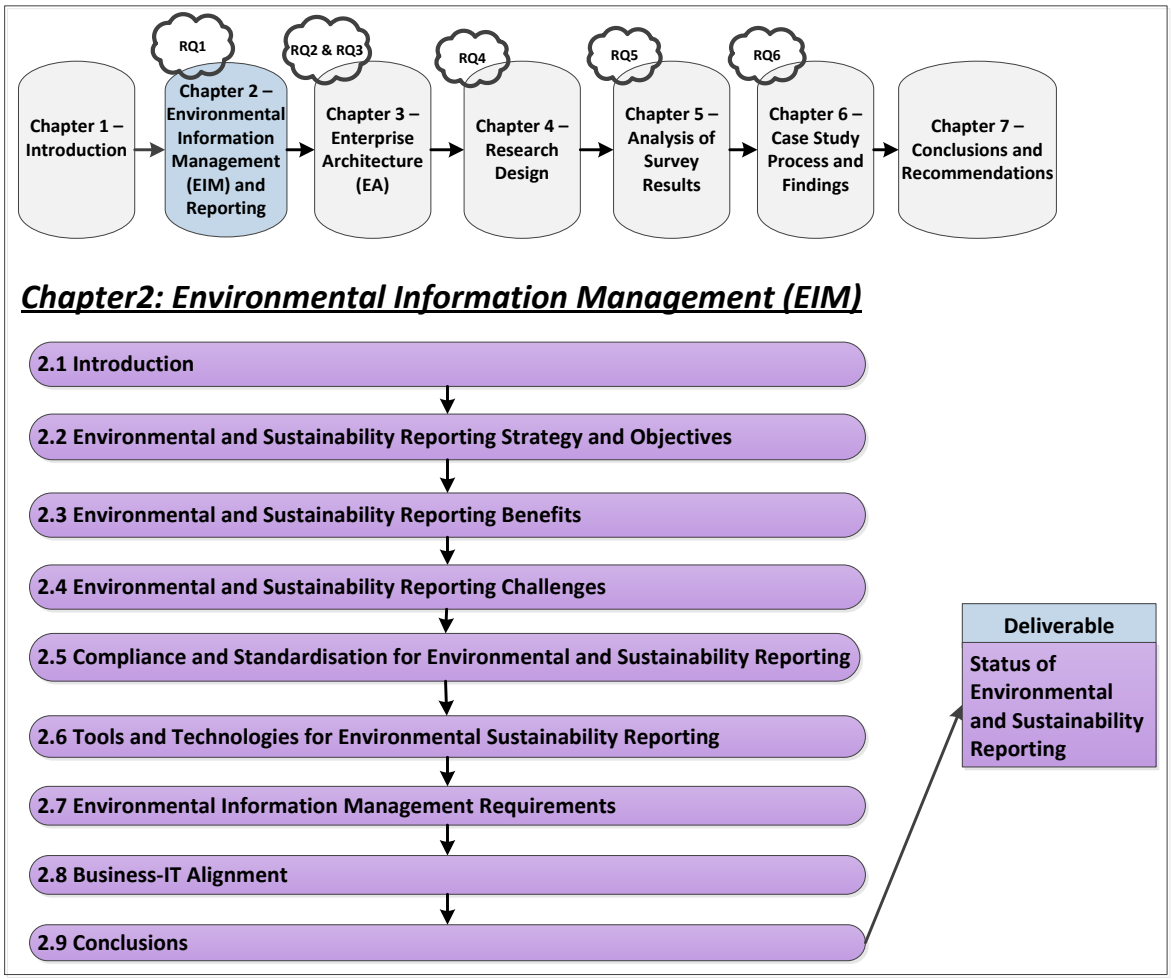


Figure 2-1: Chapter 2 Structure

In order to achieve the benefits of environmental sustainability reporting, organisations will have to overcome some challenges (Section 2.4). The main challenges of environmental sustainability reporting are compliance and standardisation and access to quality data and information required for the reports.

Compliance and standardisation of reporting can pose several difficulties for organisations due to the varied nature and complexity of these standards (Section 2.5). One way of achieving integrated reporting is to utilise the tools and technologies that can aid the tasks involved in producing a sustainability report (Section 2.6). An examination of the challenges of sustainability reporting as well as an investigation of existing technologies can reveal the requirements for systems which must support integrated EIM (Section 2.7). However, technologies alone cannot provide a solution, since these technologies must form part of the IT strategy which must be aligned with the organisational environmental sustainability strategies (Section 2.8). Relevant conclusions will be made based on the findings from theory in this chapter (Section 2.9)

2.2 Environmental and Sustainability Reporting Strategy and Objectives

Labuschagne, Brent and van Erck (2005) identify three main areas of sustainability at four levels in an organisation. The three main areas are economic sustainability, environmental sustainability and social sustainability (Figure 2-2). At Level 1 of the framework a strategy should exist that will entail an organisation's responsibility towards a sustainable operation. Level 2 illustrates that it is necessary to have initiatives in place that will aid the Triple Bottom Line (TBL). Level 3 and Level 4 show the main categories and information that should be included within each of the three main areas of a sustainability report.

Organisations have a responsibility towards sustainable development as a corporate citizen (SAICA, 2009). Some of these responsibilities are:

- Organisations must effectively govern their operations;
- The organisation must engage external stakeholders; and
- The organisation must minimise its effect on the environment.

It is important to understand that greenhouse gas disclosure has value outside of the regulatory arena due to its utility for stakeholders, investors, customers and suppliers. Independent verification of Greenhouse Gas (GHG) emissions is important, not only for accuracy, but also for its usefulness by both internal and external stakeholders. For example: in the United Kingdom "*…over 2500 companies report their emissions to the Carbon Disclosure Project (CDP) which represents over 300 institutional investors that are concerned about climate change and the need to reduce corporate GHG emissions"* (Murugesan and Gangadharan 2012, p. 311).

It is evident that the environment should be of utmost importance to stakeholders and the community in general and to any organisation (SAICA, 2009). One way of ensuring that these environmental responsibilities are met can be through the inclusion of such responsibilities in an organisation's strategic planning and by means of environmental and sustainability reports (GRI, 2013a).

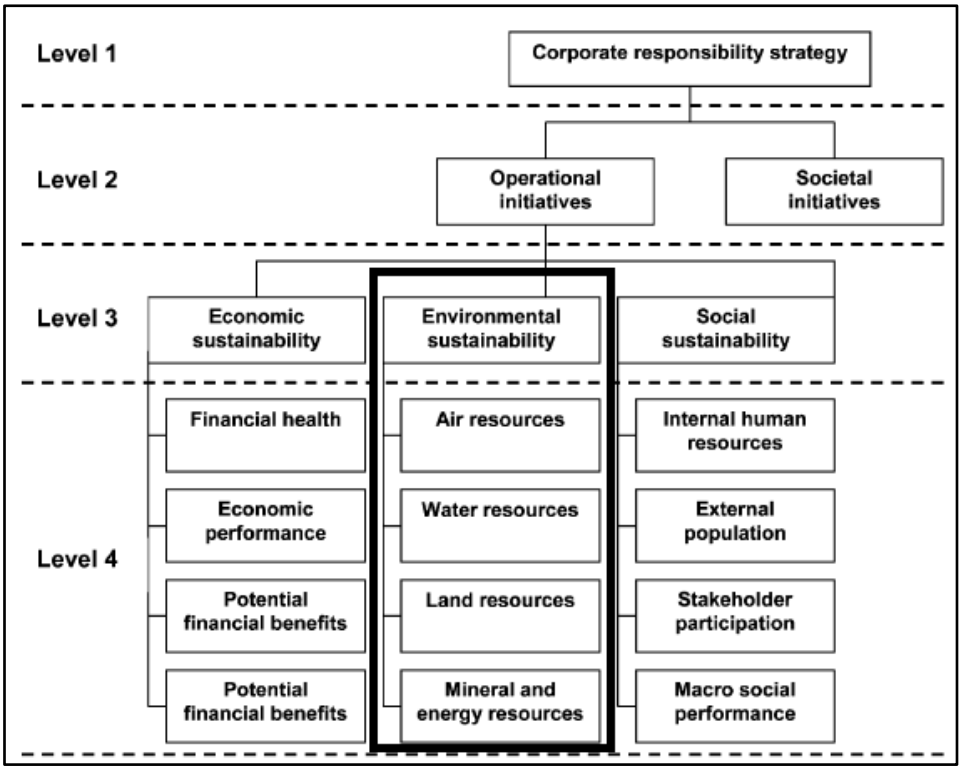


Figure 2-2: Levels of The Operational Sustainability Framework (Labuschagne *et al.*, 2005)

Magoulas *et al.* (2012) and Speshock (2010) also emphasise the importance of including sustainability reporting and environmental sustainability plans as part of the organisational strategic planning. KPMG (2008) and Ernst & Young and GreenBiz Group (2012) agrees that the sustainability reporting and environmental sustainability risks and opportunities should be aligned with the organisations overall strategy. Additionally, organisations must be encouraged to embed their overall sustainability strategy into the core strategy of their business. For example, they must get buy-in and support from managers to incorporate a "Green" or an "environmental sustainability" strategy into the organisational strategy.

Sustainability reporting concerns are seen as a global trend and pose a challenge to managers (KPMG, 2011). Sustainability reporting is *"the practice of measuring, disclosing, and being accountable to internal and external stakeholders for organizational performance towards the goal of sustainable development. A sustainability report provides a balanced and reasonable representation of the sustainability performance of a reporting organisation – including both positive and negative contributions"* (GRI, 2011b, p. 43).

Organisations on a global scale are required by legislation to report on their impact on the environment and on their social and economic endeavours (Rea, 2012). The King III report was released in 2009 emphasising the 'apply or explain' approach which shows that all organisations irrespective of the size, industry or type are to report on their TBL (Elkington, 1994). Furthermore South African organisations listed on the Johannesburg Stock Exchange (JSE) are required by law to report on the TBL in a sustainability report annually (Sonnenberg and Hamann, 2006). The JSE is the first sustainability index in South Africa where its top 160 listed companies can be viewed. The JSE sustainability index is based on three broad objectives (Sonnenberg and Hamann, 2006):

- To highlight companies from the JSE All Share Index with good sustainability practices;
- To provide the basis for financial Socially Responsible Investment (SRI) products; and
- To satisfy the need to find an objective and accepted method of measuring the sustainability performance of listed companies.

JSE listed organisations have become a reference as organisations which have experience in producing sustainability reports (KPMG, 2008). Therefore these organisations can be used in some cases as a best-practice for the non-listed organisations that have to apply or explain their sustainability performance.

Sustainability reports should reveal the outcomes and results of an organisation's commitments, strategy, and management approach that happened within the reporting period of an organisation. Several objectives of sustainability reporting have been identified (Deloitte and Touche, 2002; GRI, 2011a; KPMG, 2008; Speshock, 2010). Rea (2012) reports that the response rate of organisations toward economic reporting is much higher (almost double) than the response rate toward environmental reporting.

Eight common objectives of environmental sustainability reporting were identified. The first objective is to benchmark and compare sustainability performance internally as well as externally between different organisations, over time, in terms of standards and other regulatory factors (Deloitte and Touche, 2002; KPMG, 2008; Speshock, 2010). The seven other objectives for environmental sustainability reporting identified are:

- To improve communication and dialogue with stakeholders about sustainability by using the sustainability report as a dialogue tool (Deloitte and Touche, 2002);
- To improve sustainability marketing (Speshock, 2010);
- To allow stakeholders to use the reports to assess companies in terms of standards and other regulatory factors (GRI, 2011a);
- To initiate programmes to eliminate hazardous substances in materials and parts purchased (Deloitte and Touche, 2002);
- To increase sustainable use of natural resources (for example, land, forests and animal population) (Deloitte and Touche, 2002);
- To understand how the company influences and is influenced by expectations about sustainable development (KPMG, 2008); and
- To control production processes with regard to emissions/effluents control and waste minimisation (Speshock, 2010).

The main environmental sustainability reporting strategy is for organisations to report on their impact on the environment and the measures they take to reduce or eliminate their impact. Communication with stakeholders is a key objective and success factor of sustainability reporting since the report is produced for the benefit of the stakeholders (SAICA, 2009).

Organisations must understand the value of sustainability reporting to ranking and ratings, particularly those of interest to investors. Stakeholders want to know about the organisation's response to environmental issues and the value it offers from a business perspective. Sustainability reporting is also a communication mechanism between the organisation and its stakeholders and having the report assured by a third party entity adds more value, reliability and validity (KPMG, 2008). Therefore the communication should be clear, concise and purposeful since it should represent the organisation's transparency. If organisations can address these objectives, then sustainability reporting benefits can be achieved.

2.3 Environmental and Sustainability Reporting Benefits

Many benefits have been identified regarding environmental and sustainability reporting (Table 2-1). These benefits show that organisations have to raise awareness of and focus on sustainable practices and issues in order to assist organisations to think in terms of the long term well-being of the organisation (Ernst & Young LLP and Boston College, 2013; ACCA, 2013). Organisations also have to prepare for issues that might occur in the communities of operation and focus on these issues to gain knowledge about how to deal with issues such as scarce resources. When these environmental sustainability issues are incorporated in the overall organisational strategy then strategic alignment can be beneficial for organisations as with this effort an integrated sustainability report can be produced (ACCA, 2013).

An integrated sustainability report helps organisations to demonstrate good corporate citizenship and through this they can increase their success and reduce negative social image. A positive social image can enhance the reputation of organisations. This is a sought after benefit amongst organisations which do sustainability reporting, as it provides a platform for organisations to communicate their good deeds to their stakeholders (Ernst and Young LLP and Boston College, 2013). Therefore a sustainability report can help to increase the credibility of an organisation as in addition to when it is needed for national and regional statistics purposes (KPMG, 2008).

Organisations which have a positive reputation by disclosing information in their sustainability reports to their stakeholders can also gain greater market access which also allows organisations a differentiated position and competitiveness in the market. Sustainability reporting is seen as a tool which strengthens stakeholder relationships through better communications and greater transparency which creates trust and confidence in the stakeholders towards the organisations (ACCA, 2013). Organisations also use sustainability reports to achieve better brand alignment by explaining to stakeholders what goes into the process of creating and producing a product and which suppliers were involved in achieving such success.

Table 2-1: Sustainability Reporting Benefits

Sustainability Reporting Benefits	**References**
Raises awareness of and focus on sustainable practices and issues	Ernst & Young LLP and Boston College (2013) ACCA (2013)
Strategic alignment	ACCA (2013)
Demonstrating good corporate citizenship	Ernst & Young LLP and Boston College (2013)
Reputation enhancement	
Market access	
Competitiveness	
Strengthens stakeholders relationship	ACCA (2013)
Greater transparency	
Better brand alignment	
Compliance with legal and other requirements	Ernst & Young LLP and Boston College (2013)
Improved efficiency	ACCA (2013)
Help to set targets and Key Performance Indicators (KPIs) to reduce risk and identify opportunities	
Improved productivity	Ernst & Young LLP and Boston College (2013)

Organisations are able to achieve better brand alignment when they comply with legal and other requirements such as internal organisational requirements (Ernst and Young LLP and Boston College, 2013). Compliance with requirements can lead organisations to gain new knowledge which leads to achieving improved efficiency in the organisational processes and to achieving quality information to report on in the environmental and sustainability reports.

Environmental and sustainability reports also help to set targets and Key Performance Indicators (KPIs) to reduce risk and identify opportunities (ACCA, 2013). Finally it is seen that using reporting to communicate with employees also helps with improved productivity, meaning that employees feel important and part of the organisational decision-making process which increases the number of pleasant workers and sometimes voluntary work is done.

The environmental sustainability benefits identified in this research will be used as categories whereby the qualitative benefits which will be identified in the survey study will be coded and matched to the categories for the environmental sustainability benefits. In order to achieve these environmental sustainability benefits, organisations have to address their environmental and sustainability reporting challenges.

2.4 Environmental and Sustainability Reporting Challenges

Efforts regarding sustainability reporting have grown tremendously over the past decades, however organisations are still faced with several challenges (ACCA, 2013; KPMG, 2008; UNEP *et al.*, 2010; Weybrecht, 2010). The common challenges that organisations need to overcome are listed in Table 2-2.

Table 2-2: Environmental and Sustainability Reporting Challenges

Environmental and Sustainability Reporting Challenges	References
Compliance and Standarisation	KPMG (2008) UNEP *et al.* (2010)
Quality of data	Ernst & Young LLP and Boston College (2013) KPMG (2008) Purvis *et al.* (1999) Solsbach *et al.* (2011)
Data collection and access to information	Ernst & Young LLP and Boston College (2013) Weybrecht (2010)
Moving from costs to revenue	Weybrecht (2010)
Traditional accounting systems	Weybrecht (2010)
Transparency and disclosure to stakeholders	GRI (2013a) UNEP *et al.* (2010)
Communication between departments	Weybrecht (2010)
Short-term versus long-term	KPMG (2008) UNEP *et al.* (2010) Weybrecht (2010)
Buy-in to disclose data	Ernst & Young and GreenBiz Group (2012) Ernst & Young LLP and Boston College (2013) KPMG (2008)
Skills shortage	ACCA (2013)
Quantifying the qualitative	KPMG (2008) Weybrecht (2010)

A challenge to sustainability reporting identified in studies by KPMG (2008) and UNEP *et al.*, (2010) is compliance and standardisation. The needs and expectations of stakeholders cannot always be captured into certain sections in a compliance-based report, as some of the processes might be captured in different systems which are not seamlessly aligned and integrated into a standardised report (KPMG, 2008; UNEP *et al.*, 2010). The changing regulatory requirements increase the difficulty of delivering adequate sustainability reporting information.

Other challenges relate to quality of data (Ernst and Young LLP and Boston College, 2013; KPMG, 2008; Purvis *et al.*, 2000; Solsbach *et al.*, 2011). A lack of available information can result in poor quality of the data being represented in a sustainability report. The quality of the information is vital to the stakeholders who are the recipients of the report.

Most organisations use third party assurance to validate a report in order to ensure accuracy and completeness of the data (Ernst and Young LLP and Boston College, 2013; KPMG, 2008; Purvis *et al.*, 2000; Solsbach *et al.*, 2011). Organisations struggle to gather, store and present or report environmental sustainability information effectively and efficiently (Rea, 2012). These challenges are often caused by information silos and inconsistencies due to un-integrated systems which cause the challenge. The necessity is to integrate, store, retrieve and present environmental information (Carlson *et al.*, 2001; Solsbach *et al.*, 2011).

Data collection and access to information is necessary for the long-term view, for decision-making and for the auditing process in organisations but sometimes the information and the source of the information are not available (Ernst and Young LLP and Boston College, 2013; Weybrecht, 2010). A study by A4S (2009) also showed that the data required for sustainability reports already exist in organisational IS and that this could reduce the time to retrieve the data, create and present these reports.

Organisations have to move from cost to revenue by addressing the business value and benefits of sustainability reporting. Thus in the long-term increased revenue can be gained despite the initial costs involved in the environmental sustainability process (Weybrecht, 2010). Legacy systems such as traditional accounting systems were not designed to incorporate the data of the environmental sustainability process. Therefore these systems are often isolated and have to be updated and evaluated separately, for example, data on waste management and compliance with laws and insurance (Weybrecht, 2010). If organisations do not have the information systems in place to help them disclose such information in an environmental sustainability report then issues arise amongst stakeholders such as trust towards the organisations. Stakeholders rate organisations in terms of how earnestly they can disclose sustainability related information without having regulations enforced.

Disclosure of information is measured by how transparent an organisation's sustainability report is. Transparency is most sought after by stakeholders and could be a key benefit for an organisation to achieve (GRI, 2013a; UNEP *et al.*, 2010). Inconsistencies in how sustainability information is being communicated are evident due to lack of communication between departments such as the sustainability specialist and the accountant. Therefore these departments may have silo objectives for sustainability reporting (Weybrecht, 2010). Short-term and long-term objectives need to be identified so that organisations can achieve an integrated environmental sustainability report.

A shift is needed from a short-term state of mind to a long-term view, especially from the perspective of accounting principles. Long-term, less tangible, environmental and social costs must be included in the balance sheet (KPMG, 2008; UNEP *et al*., 2010; Weybrecht, 2010). A sustainability report is produced for executives, shareholders, investors, communities, government and others. These stakeholders should be part of the decision-making process for data that should be disclosed in the sustainability report, therefore buy-in to disclose data from all stakeholders is an important part of the entire reporting process (Ernst and Young LLP and Boston College, 2013; Ernst and Young and GreenBiz Group, 2012; KPMG, 2008). Another challenge for organisations concerning sustainability reporting is the skills shortage. Professionals must understand the requirements of creating a comprehensive sustainability report and what organisations are actually willing to disclose (ACCA, 2013).

Converting typical sustainability issues into accounting form and thus having to quantify qualitative data regarding, for example biodiversity, is a challenge for organisations (Weybrecht, 2010). Organisations compare data across industries regarding sustainability issues that were disclosed for competitive reasons, benchmarking and possibly seek solutions (KPMG, 2008).

The main objective of sustainability reporting for organisations is to achieve an integrated report (GRI, 2013a). Therefore this shows that all facets of information about the TBL should be included, not in isolation, but in a coherent and integrated fashion. The environmental sustainability reporting challenges (Table 2-2) pose a threat to meeting this objective. Several studies identify the need for the strategies and resources of organisations to be aligned in order to overcome the environmental sustainability challenges identified (Esty and Simmons, 2011; KPMG, 2008; Murugesan and Gangadharan, 2012; Speshock, 2010; Weybrecht, 2010).

A case study was done on "*Connected Reporting in Practice*" (A4S, 2009, p. 2), in which a wide range of industries and public sectors participated. The findings of this study showed that all the participants wanted to "*to link sustainability reporting to financial and strategic reporting in a connected way*". This study revealed that when these organisations mapped their reporting strategy to their business strategy, it improved their sustainability awareness and this was achieved "*as a result of adopting the CRF (Connected Reporting Framework)*". The environmental sustainability challenges identified in this research will be used as categories whereby the qualitative challenges which will be identified in the survey study will be coded and matched to the categories for the environmental sustainability challenges. Many environmental sustainability reporting standards and tools such as frameworks exist to help organisations with compliance and standardisation of environmental and sustainability reporting.

2.5 Compliance and Standardisation for Environmental and Sustainability Reporting

Compliance and standardisation of the sustainability report is one of the many challenges that organisations are faced with. Standards for sustainability reporting exist both on a global and a regional level for different countries and each country has its own accepted mandatory and voluntary standards. These standards were established to assist organisations with their sustainability reporting responsibilities and requirements (KPMG, 2008; UNEP *et al.*, 2010). Table 2-3 illustrates the explanations of each of the different types of standards on a global level and, both the mandatory and voluntary standards applicable to South African organisations. Global standards are evolving and this is an indication that sustainability reporting is becoming a mature practice on an international level (UNEP *et al.*, 2010). Internationally accepted standards exist to aid organisations with their sustainability reporting.

The Global Reporting Initiative (GRI) is the most widely used standard in the world. It is regarded as the most recognised framework for sustainability reporting. The framework contains principles and indicators which organisations can use for measuring and reporting their economic, environmental and social performance (GRI, 2013a; UNEP *et al.*, 2010). The GRI (2013b) show the latest version for the reporting principles and standard disclosures known as GRI G4. All organisations small, medium and large from different industry types can use these principles and standards to disclose their organisational sustainability performance. The GRI G4 standards also include an implementation guide on how to create a sustainability report.

The International Organisation for Standardisation (ISO) has created over 17500 standards and addresses issues across many sectors such as: "*ISO 9000 series on quality management, ISO 14000 series on environmental management, ISO 22000 on food safety management, ISO 24510 standards on water supply and treatment services and the new ISO 31000 standard on risk management*" (UNEP *et al.*, 2010, p. 20). A study by ISO (2012) shows that South Africa is taking the lead in the whole of Africa with the most ISO 14001 certificates. Europe also uses the EMAS (Eco-Management and Audit Scheme) based on the ISO14001 (series on environmental management which indicates specific requirements for environmental reporting and communication) as part of a regulatory approach. A recently added ISO standard was the ISO 26000 series on Social Responsibility.

Table 2-3: Sustainability Reporting Standards, adapted from UNEP et al. (2010)

GLOBAL STANDARDS	**PER ORGANISATION/COUNTRY**
Voluntary	
The Global Reporting Initiative (GRI)	The Global Reporting Initiative (GRI)
The International Organisation for Standardisation (ISO)	The International Organisation for Standardisation (ISO)
United Nations (UN) Global Compact	United Nations
UN Principles for Responsible Investment (UNPRI)	
The Organisation for Economic Co-operation and Development (OECD)	France
The Coalition for Environmentally Responsible Economies (CERES) Principles	United States
The SA8000 standard	
AA1000 AccountAbility Principles Standard (AA1000APS), 2008	United Kingdom
The Carbon Disclosure Project (CDP)	
The Extractive Industries Transparency Initiative (EITI)	Norway
GLOBAL ASSURANCE STANDARDS	**PER ORGANISATION/COUNTRY**
Voluntary	
The International Standard on Assurance Engagements (ISAE) 3000	The International Auditing and Assurance Standards Board (IAASB)
AA1000 Assurance Standard (AA1000AS), 2008	United Kingdom
REGIONAL STANDARDS APPLICABLE TO SOUTH AFRICAN ORGANISATIONS	
Mandatory standards	
National Black Economic Empowerment Act, 2003	
Employment Equity Act , 1998	
Companies Act, 2008	
The Consumer Protection Bill, 2009	
The Public Finance Management Act (PFMA), 1999	
Mineral Resources and Petroleum Bill, 2009	
Voluntary standards	
The King Report on Corporate Governance, 1994	
The Johannesburg Stock Exchange (JSE) Socially Responsible Investment Index (SRI Index), 2004	
Carbon Disclosure Project (CDP), 2007	
Industry Specific Black Economic Empowerment Charters, 2003	
State-Owned Enterprise Shareholder Compacts, 2002	

The environmental standards are categorised as the ISO 14000 family and can be used by types of organisations both private and public. The ISO 14001 standard involves the Environmental Management System (EMS) which is an internationally accepted standard and is based on the management of the impact of organisations and how to display effective and efficient environmental management. Organisations can certify themselves as ISO 14001 compliant which indicates that they comply with environmental regulatory laws (Zutshi, 2004). The ISO 14004 provides additional guidance and explanations to ISO 14001, hence it complements ISO 14001. The ISO 19011 is the auditing standard. It provides the assurance that the EMS has been implemented and maintained properly. The standard provides guidance "*on principles of auditing, managing audit programmes, the conduct of audits and on the competence of auditors*" (ISO, 2009, p. 6).

The ISO 14000 group of standards can be used as guides in an organisation to focus the environmental strategy of an organisation and can be mapped to the environmental sustainability reporting objectives (Table 2-4). The ISO 14063 provides guidelines for environmental communication, thereby assisting with improving stakeholder communication.

Table 2-4: Standards for Supporting Environmental Sustainability Reporting Objectives

Environmental Sustainability Reporting Objectives	Environmental Reporting Standard (ISO 14000)
Benchmark and compare sustainability performance internally as well as externally between different organisations over time in terms of standards and other regulatory factors	**ISO 14031 –** Environmental performance
Improve communication with stakeholders about sustainability using the sustainability report as a dialogue tool	**ISO 14063 –** Environmental communication
Improve sustainability marketing	**ISO 14031 –** Environmental performance
Initiate programmes to eliminate hazardous substances in materials and parts purchased	**ISO 14040 -** Life-cycle assessment (LCA)
Increase sustainable use of natural resources (for example, land, forests and animal population)	**ISO 14040** **ISO 14031 –** Environmental performance
Understand how the company influences and is influenced by expectations about sustainable development	**ISO Guide 64 –** Environmental aspects in product standards
Control of production processes with regard to emissions/effluents control and waste minimisation	**ISO 14040** **ISO 14064 –** parts 1, 2 and 3 are international GHG

The ISO 14031 standard gives guidance on the evaluation of environmental performance. It uses certain performance indicators as criteria that an organisation can then use to do assessment. The information is thus used for reporting about the organisation's environmental performance and can be used to improve sustainability marketing and for benchmarking an organisation against others. Environmental labels and declarations is the ISO 14020 standard which addresses approaches to "*eco-labels (seals of approval), self-declared environmental claims, and quantified environmental information about products and services*" (ISO 2009, p. 6). Life-cycle assessment (LCA) is captured by the ISO 14040 standard. It is clear that the environmental aspects of an organisation's processes cannot be described without addressing those of the products and services (ISO 14001). LCA is used as a tool for the evaluation of products and services from the start of the product to the end of the product's life cycle. This standard gives information to organisations about reducing the holistic environmental impact of its products and services.

The ISO 14064 standard consists of three parts – "*parts 1, 2 and 3 are international greenhouse gas (GHG) accounting and verification standards which provide a set of clear and verifiable requirements to support organisations and proponents of GHG emission reduction projects*" (ISO 2009, p. 6). ISO 14065 complements ISO 14064.

The 14065 standard provides accreditation to organisations that apply GHG validation and verification. ISO 14063 captures environmental communication which helps organisations to link to external stakeholders. ISO Guide 64 includes environmental aspects in product standards. It is primarily aimed at standards developers, but the guidance can also be used by designers and manufacturers.

The United Nations (UN) Global Compact consists of ten principles concerning human rights, labour, the environment and anti-corruption by which organisations can align their operations and strategies. It is known as the largest voluntary initiative for corporate citizenship (United Nations Global Compact, 2011). The UN Principles for Responsible Investment (UNPRI) is regarded as an investor initiative and is in partnership with United Nations Environment Programme (UNEP) Finance Initiative and UN Global Compact. These principles are voluntary and provide investors with assistance to integrate their environmental, social and corporate governance (ESG) issues into investment processes and ownership practices (PRI Initiative, 2012).

The Organisation for Economic Co-operation and Development (OECD) encourages timely, regular, reliable and relevant disclosure of financial and non-financial performance about environmental and social issues (Leipziger, 2010; UNEP *et al.*, 2010). These guidelines are suitable for multi-national enterprises.

The Coalition for Environmentally Responsible Economies (CERES) Principles is based on a 10-point code of conduct which provides guidelines on environmental reporting (Leipziger, 2010; UNEP *et al.*, 2010). These principles were one of the forces behind the launch of the GRI in 1997. The SA8000 standard was developed by Social Accountability International, a multi-stakeholder in the Non-Government Organisation (NGO) initiative. This standard is voluntary. The SA8000 standard was established based on "*conventions of the International Labour Organisation, the United Nations Convention on the Rights of the Child, and the Universal Declaration of Human Rights"* (UNEP *et al.* 2010, p. 21).

AA1000 AccountAbility Principles Standard (AA1000APS) was issued during 2008 by the United Kingdom (UK)-based AccountAbility (AccountAbility, 2008; UNEP *et al.*, 2010). It can be used by "*organisations to develop an accountable and strategic response to sustainability, including reporting*" (UNEP *et al.*, 2010, p. 21).

It also provides auditable criteria based on the AA1000AS assurance engagement (IAASB, 2012). AA1000AS provides a "*comprehensive approach to holding an organisation to account for its management, performance and reporting on sustainability issues by evaluating the adherence of an organisation to the AA1000APS"* (UNEP *et al.*, 2010, p. 22).

The CDP is an organisation in the UK working with large corporations and shareholders to disclose greenhouse gas emissions (CDSB, 2012; UNEP *et al.*, 2010). Their main aim is to "*collect and distribute high quality information that motivates investors, corporations and governments to take action to prevent dangerous climate change*" (UNEP *et al.*, 2010, p. 21).

The Extractive Industries Transparency Initiative (EITI) that was issued during 2003 "*requires regular public disclosure of all material oil, gas, and mining payments made by companies to governments and revenues received by the governments from these companies*" (UNEP *et al.*, 2010, p. 21). This standard is based on Norway's aims to "increase transparency in transactions between governments and companies in extractive industries" (EITI, 2013; UNEP *et al.*, 2010, p. 21). Standards on a global level for assurance purposes are, the International Standard on Assurance Engagements (ISAE) 3000 and the AA1000 Assurance Standard (AA1000AS) (IAASB, 2012; UNEP *et al.*, 2010). ISAE 3000 is used by accounting firms to *"guide their assurance engagements on sustainability reports*" (UNEP *et al.*, 2010, p. 22).

The standards which are accepted nationally by South African organisations consist of both mandatory and voluntary standards (UNEP *et al.*, 2010). The National Black Economic Empowerment Act issued in 2003 is a mandatory standard whereby the government requires progress reports regarding the promotion of black economic empowerment in organisations. The Employment Equity Act, issued in 1998 requires an annual report to be submitted to the government on actions taken in an organisation that show the elimination of unfair discrimination in the workplace and affirmative action for "designated groups" such as black people, women, or people with disabilities. The Companies Act, issued in 2008, says directors of an organisation can be held responsible for poor performance and poor public disclosure of information.

The Consumer Protection Bill issued in 2009, does not have an official mandate for sustainability reporting, as this standard concerns product labelling with the right to *"disclosure and information*" (UNEP *et al.*, 2010, p. 62). This standard is however linked to the GRI G4 section on product responsibility performance indicators.

The Public Finance Management Act (PFMA) which was issued in 1999 applies to both national and the provincial governments and is based on legislative requirements for reporting to government about the management and performance of public entities. The Mineral Resources and Petroleum Bill, issued in 2009 requires affected companies to *"disclose Social and Labour Plans to government describing how they will address the social impacts of their operations during and post operation*" (UNEP *et al.*, 2010, p. 62).

The voluntary standards for organisations in South Africa include the King Report on Corporate Governance, issued during 1994. The King Report is the accepted and followed document for South African corporate governance. King III is based on "*requiring business to integrate the management of financial and non-financial issues (risk management and audit)*" as well as the focus on corporate citizenship (UNEP *et al.*, 2010, p. 63). It also requires "*integrated sustainability reporting and third party assurance. It applies to all South African companies and is a listing requirement for the Johannesburg Stock Exchange*" (UNEP *et al.*, 2010, p. 63).

The JSE Socially Responsible Investment Index (SRI Index) was issued during 2004 and requires all companies to report publicly on sustainability related issues (UNEP *et al.*, 2010). South Africa participated in the CDP since 2007 aiming at getting organisations to disclose their greenhouse gas emissions. The Industry Specific Black Economic Empowerment Charter was issued in 2003 is based on the BEE act but at an industry-specific level (UNEP *et al.*, 2010). The State-Owned Enterprise Shareholder Compacts were issued during 2002. These compacts are formed from state-owned shareholders and Government Shareholders and some compacts "*require reporting on sustainability issues*" (UNEP *et al.*, 2010, p. 64). An example of a shareholder compact is a document which must contain the key performance objectives, measures and indicators agreed upon between a public entity and an executive authority (CSIR, 2009).

The daunting task for organisations is to keep up to date with the all the regulatory requirements and to present their compliance and non-compliance (UNEP *et al.*, 2010). The problem here is that if an organisation does not do this, the benefits of sustainability reporting will not be achieved. Another daunting task is to seamlessly integrate these standards and regulations into a single report and to map them to organisational strategies. KPMG (2008) proposes a model (Figure 2-3) which can be used by organisations to align their sustainability reports to the relevant standards and regulations.

This can be used as a hybrid approach as many organisations want a customised solution for reporting and in addition to gain credibility, quality assurance and a reference across different standards or methods used. Figure 2-3 also illustrates that an organisation can be placed on different quadrants based on the stakeholders' perception of whether the organisation followed sustainability standards and regulations (KPMG, 2008).

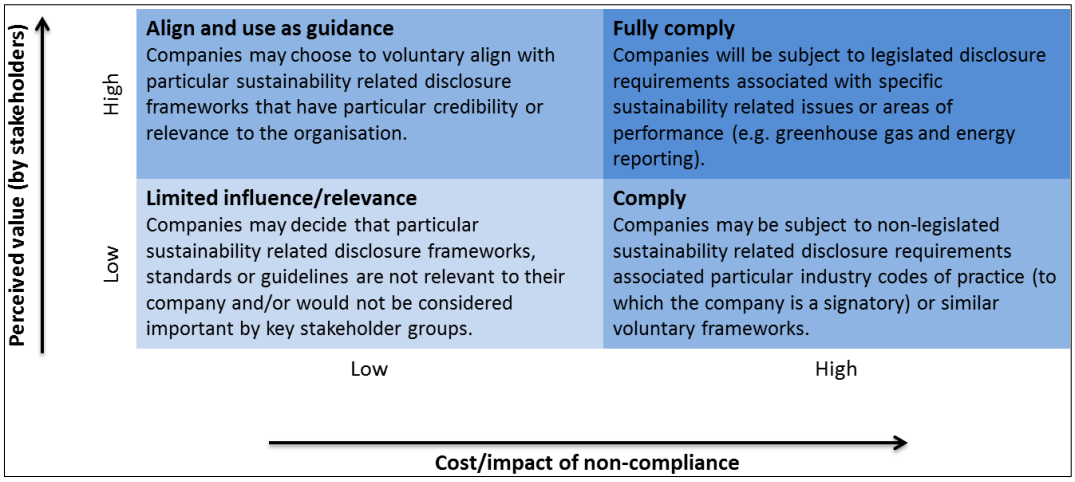


Figure 2-3: Sustainability Report Alignment with Relevant Standards and Regulations, adapted from KPMG (2008)

Organisations which achieve to "*Align and use…*" voluntary standards and disclose such sustainability information as well as "*Fully comply*" with standards and regulations are highly esteemed amongst stakeholders (KPMG, 2008, p. 19). Those organisations that choose to comply with limited standards and regulations and disclose only certain information about their sustainability practices are perceived by stakeholders to have a low value. In order to help organisations address the challenge of compliance with regulations and standardisation of reporting, organisations need to use tools and technologies that will enhance their environmental and sustainability reporting practice. The next section investigates several available tools and technologies for environmental and sustainability reporting.

2.6 Tools and Technologies for Environmental Sustainability Reporting

One standard for sustainability reporting is the Prince's Accounting for Sustainability Project (A4S) which was launched by the Prince of Wales (A4S, 2009). The project assists organisations with tools and guidelines to establish their sustainability strategies and practices. The project's beliefs are that alignment between the organisation's strategies, financial performance and sustainability impacts can only be achieved when the environmental and social factors can be integrated into the management reporting of the organisation and also into the organisation's strategy.

Organisations have to address how they can align their environmental sustainability strategies with their organisational strategies by using tools and technologies to support this effort. Recent studies (Rea, 2012; Ernst and Young and GreenBiz Group, 2012) have shown that while the number of organisations doing sustainability reporting is increasing, the tools, technologies and approaches used to do these reports are still lacking and have not reached the required standard.

Several tools for sustainability reporting exist, especially customised tools for EIM (Weybrecht, 2010). Organisations are mostly using spreadsheets, emails and phone calls to retrieve, format and manage their sustainability reporting needs, including the environmental section of the report (Ernst and Young and GreenBiz Group, 2012). Therefore there is a need to investigate IS and tools that will be able to more efficiently assist organisations in their environmental sustainability reporting efforts.

Speshock (2010) proposes that the IT department is able to offer the systems and architectures for the necessary information management for environmental sustainability reporting. In order for these types of systems to be created, a top-to-bottom approach should be followed where the planning and strategies for an organisation's environmental sustainability initiatives and sustainability reporting needs should be included in the architecture of the information management system. It is also described that such systems will be able to assist an organisation's functions to become "Greener". For example, streamlining the supply chain processes and the systems required to carry out these tasks could reduce the resource needs that in turn reduce energy consumption that is *"improving shipping and transport of goods and products that reduces fossil fuel consumption"* (Speshock, 2010, p. 60). Employees are key stakeholders in sustainability engagement and having *systems to share tools and lessons learnt* across the organisation can help to engage employees at all levels (Esty and Simmons, 2011). Some characteristics of what an enterprise reporting system should be capable of are (Speshock, 2010):

- Internet, extranet, and intranet reporting abilities;
- Operational and production reporting;
- Analytic and strategic reporting;
- Business reporting;
- Central reporting repositories to create one final version of reports;
- Multilingual support;
- Exporting of report content;
- Secured reporting abilities;
- Heterogeneous report data source selection; and

- Environmental sustainability compliance report templates and adherence to reporting standards and requirements.

Ernst & Young and GreenBiz Group (2012) also stress the importance of a sustainability reporting system that can help achieve transparency and accuracy of reporting, at a level similar to the financial reports of an organisation. Several systems can help organisations to automatically collect and present data regarding their environmental impact. Examples of these systems are: Enterprise Resource Planning (ERP) systems, performance dashboard and scorecards such as environmental sustainability dashboards such as Microsoft Dynamics AX (Speshock, 2010). Dashboards can also improve environmental awareness and business processes such as accounts payable and inventory management (Speshock, 2010).

The Ernst & Young and GreenBiz Group (2012) study identified that the tools and technologies for environmental sustainability reporting are not implemented in an integrated manner within organisations. Therefore organisations are faced with the challenges of not have the proper tools and technologies in place to assist with their environmental sustainability reporting process. First, organisations have to identify their EIM requirements in order to identify which tools and technologies will be best for their information needs.

2.7 Environmental Information Management Requirements

The quality of information for sustainability reporting is a challenge for many organisations (Section 2.4). This challenge is linked to having the information readily available and to specify the source of the information for quality assurance purposes. In order to address these challenges and implement systems which facilitate environmental reporting and support the organisation's strategy, it is important to have a baseline for managing environmental data and information (Speshock, 2010).

The requirements for environmental information of stakeholders must therefore be investigated to establish how they can be included in the organisation's overall strategy (Murugesan and Gangadharan, 2012; Speshock, 2010). The main objective for environmental reporting is to communicate information to the relevant stakeholders. Weybrecht (2010) reports that in order to achieve this objective, appropriate systems are needed to retrieve, create and report environmental information.

In order to establish the state of an organisation's environmental sustainability information, Speshock (2010) proposed a baseline (Figure 2-4). The purpose of the baseline is to provide an organisation with assistance to define, collect and structure environmental data. All the necessary environmental data should be collected at the source (that is systems, documents repositories). After the data collection, collaboration with personnel should take place to determine whether additional environmental data is needed for the analysis. Gaps in the data that were collected that might impact the data analysis also need to be identified. The data should then be analysed by using a predefined process. KPIs are created for comparison of data at a later stage and software packages such as business performance management tools are used to create dashboards to display the data. A draft assessment should be prepared that is in-line with the standard the organisation uses for its environmental performance in order to assess the collected data. The draft is then reviewed and modifications are made where needed. Finally the data assessments are finalised and the final draft should then be made available online or on portals. The environmental data can then be grouped into different aspects required for a report.

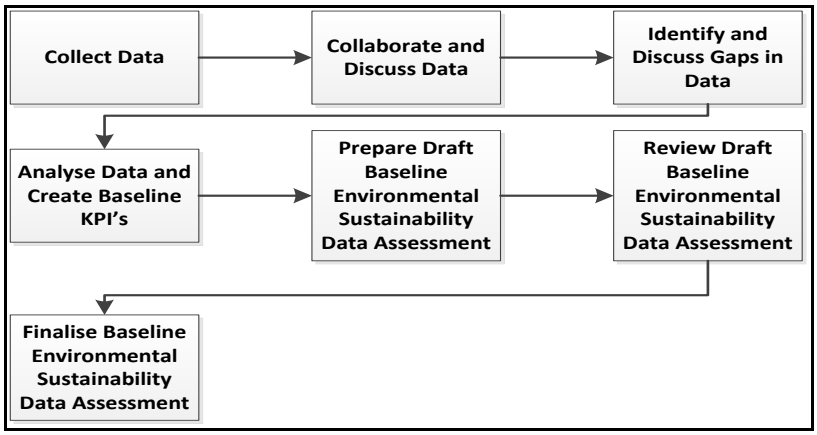


Figure 2-4: Baseline Environmental Sustainability Data Assessment (Speshock, 2010)

The main objective regarding environmental information is how to gather such information and in turn present it to the relevant stakeholders (KPMG, 2008). An insight is given in a report by KPMG (2008) and it is clear that different stakeholders have different information needs (Table 2-5). The sustainability report is a valuable information source especially for strategic decision-making processes to the Board and Senior Management teams (KPMG, 2008). Investors are interested in the risks that they take and their Return on Investments (ROIs). The sustainability report can be used to provide investors with the information that they need and in turn can be used as informative relevant information to other stakeholders.

The employees and their unions are interested in the performance of the organisation and whether the organisation will be sustainable, thus securing the future employment of workers (that is information regarding remuneration, retirement benefits, opportunities and other matters.). They are also interested in whether the organisation is a responsible citizen, hence contributing to society, being environmentally responsible and economically successful. Governments need all the relevant information about an organisation's performance, in order to set policies for competition, for taxation purposes, the environment, consumers and social affairs.

Table 2-5: Stakeholders and their Information Requirements (an insight), adapted from KPMG (2008)

Stakeholder	**Need**
Board and senior management team	Strategic decision-making processes
Investors	Risk and potential returns
Employees	Performance of organisation
Governments and regulators	Organisation's performance to set policies
Customers	Products, services and activities
Lenders	Risk factors
Suppliers	Risks and opportunities
Non-government organisations (NGOs)	Understanding the organisational operations
The public	Organisational impact

Long- term customers become interested in an organisation's processes and prosperity linked to their products and services and activities (KPMG, 2008). Customers also want to be assured that organisations are doing their part in the society and if the products are environmentally friendly. Sustainability information can help lenders to determine risk factors associated with the organisation's business practices. Sustainability reports can help suppliers better to understand risks and opportunities that may affect their businesses, for example, by increasing their risk exposure by associating them with questionable business practices. A report can also inform suppliers of the demands they may face from the organisation as part of its supply chain, for example, relating to carbon neutral positioning and ethical behaviour of a customer. NGOs often use sustainability reports as a basis for understanding companies' values, principles, attitudes, performance and goals.

Companies affect and interact with the public in many ways. For example, by providing employment opportunities, sourcing inputs from local suppliers and supporting community projects. The public is also potentially interested in issues such as environmental performance (for example noise, pollution) (KPMG, 2008). Organisations can manage their environmental performance by using an EMS.

An EMS can be used to assist stakeholders with their information needs (ISO, 2004; ISO, 2009; El-Gayar and Fritz, 2006). Marx Gómez and Teuteberg (2010) propose an EMS (Figure 2-5) which consists of components and supplementary components. The components represent the typical information areas that can be included in an EMS. Environmental politics is the action plan or statement of the organisation's commitment to the environment (Stapleton *et al.*, 2001). Eco-balances are used for analysis purposes, to determine the critical environmental impacts. Eco-balances are determined by calculating the relevant environmental index number, where the environmental index number represents an environmental situation. The eco-balances of an organisation can comprise the input and output materials used to produce a product or service.

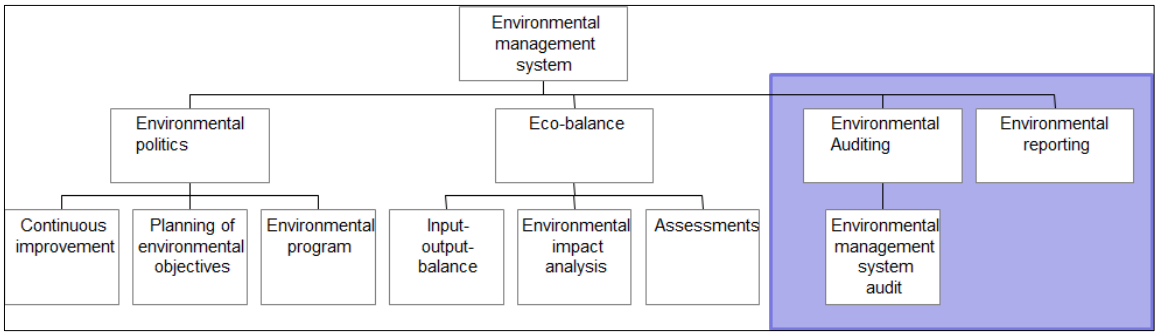


Figure 2-5: An EMS, adapted from Marx Gómez and Teuteberg (2010)

An environmental audit can include sections on "water supply, wastewater, chemical storage, waste management, hazardous materials management, spill control and emergency planning, air pollution control and contaminated land" (European-Commision 2000, p. 149). The auditing process consists of definition of the scope definition; experienced teams; the audit plan which includes communication with the site members, the preparation of the site and an audit questionnaire. The preliminary background information about the facility and the operations of an organisation have to be collected. The process also includes a discussion with the site personnel and observation of conditions regarding the surrounded areas for review purposes. When the procedure is about to end, the auditors identify any potential concerns and the necessary corrective actions. The environmental reports will thus include a plan for preparation to prevent or to solve any such concerns. The plan should also include regular audits as well as follow-up action plans. The environmental report should include details regarding the organisation's environmental impacts and the measures taken to measure and monitor these impacts (DEAT, 2005; UNEP *et al.*, 2010).

Environmental information is grouped into aspects within the GRI G4 guidelines document, and these aspects are known as environmental (EN) performance indicators (GRI, 2013a). There are 30 standard EN indicators known as the GRI G4 EN indicators (Appendix B). The various categories and indicators of environmental information represent the inputs, outputs and the modes of the environmental impact from organisations (GRI, 2013a). Energy, water and materials are the inputs commonly needed and used by most organisations and its outputs are captured under the aspects of Emissions, Effluents and Waste. Biodiversity is also classified as an input, but only to a certain extent if it is represented as a natural resource. Transport and products and services affected by parties such as customers or suppliers in the logistics services can also represent an organisation's impact on the environment. The measures that an organisation takes in order to manage their environmental performance are grouped under the Overall and Compliance aspects in the GRI G4 document for guidelines.

The EN indicators that will be included in the focus of this study are based on the study of Rea (2012), reporting that South African companies were particularly challenged when responding to the energy, emissions and water consumption EN indicators. This was evident due to water and energy scarcities faced by the country and organisations had to find ways to deal with this impact on the overall well-being of their business operations. Therefore this study will include the following EN indicators in the survey study:

- EN3- Direct energy consumption by primary energy source;
- EN4 - Indirect energy consumption by primary source;
- EN8 - Total water withdrawal by source;
- EN9 - Water sources significantly affected by withdrawal of water;
- EN10 - Percentage and total volume of water recycled and reused;
- EN16 - Total direct and indirect greenhouse gas emissions by weight;
- EN17 - Other relevant indirect greenhouse gas emissions by weight; and
- EN18 - Initiatives to reduce greenhouse gas emissions and reductions achieved.

2.8 Business-IT Alignment

Environmental and sustainability reporting can provide many benefits to organisations and IT resources can be used to support this process (Murugesan and Gangadharan, 2012; Speshock, 2010). However IT and business, including sustainability strategies, must be aligned with each other and this business-IT alignment has become a common challenge today for managers and Chief Information Officers (CIOs) (ITWorld, 2013).

Land *et al.* (2009) support this argument and add that the alignment problem in organisations has emerged from business-IT alignment issues to an alignment problem in the entire organisation that is described as an enterprise wide alignment problem. Business strategy and IT must be aligned to facilitate the most effective use of technology and tools available (Speshock, 2010; Velitchkov, 2008; Wang *et al.*, 2008). Speshock (2010) supports the business-IT alignment approach and recommends the alignment of an organisation's mission with work processes, decisions, information and technology (Figure 2-6). It is proposed that IT should be seen as the support provided to the environmental sustainability initiative. The environmental sustainability initiative is the process that focuses on the needs, processes and strategic objectives of the organisation and reengineers these aspects where applicable.

The business-IT alignment model proposed by Speshock (2010) can be separated into the three process levels of an organisation, namely, the strategic, operational and technological levels (Harmon, 2010). Speshock (2010) proposes, that the alignment between the technology of an organisation and the information requirements, decisions, work processes and mission or strategy, is important to obtain a holistic view of an organisation.

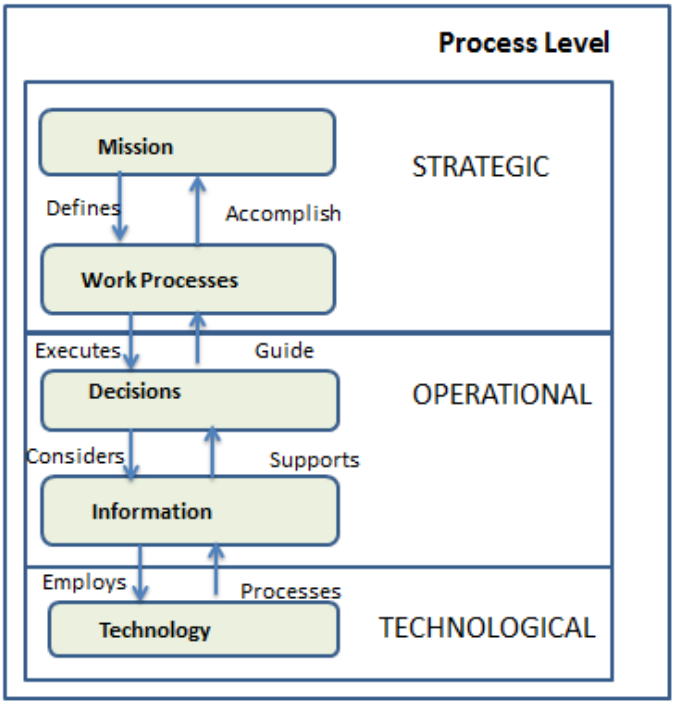


Figure 2-6: Alignment of IT with an Organisation's Strategy, adapted from Speshock 2010)

Business-IT alignment is described by Silvius *et al.* (2009, p. 13) as *"the degree to which IT applications, infrastructure and organisation enable and support the business strategy and processes, as well as the process to realise this"*. This approach is also supported by several other studies (Iyamu, 2011; Kattenstroth, 2012; Plazaola *et al.*, 2008; Wang *et al.*, 2008).

The use of EA for closing the gap between strategy definition and between business and IT at a strategic and operational level has been proposed by Velitchkov (2008) and Ross, Weill and Robertson (2006). The use of EA to support business-IT alignment has been directly linked to the success of organisations (Iyamu, 2011). This argument is supported by Doucet *et al.* (2008), Schekkerman, (2011b), Silvius *et al.* (2009) and Wang *et al.* (2008).

Doucet *et al.* (2008) describe the business-IT alignment concept using a model called "*Coherecy Management*". This model contains three components which refelct the alignment namely:

1. Alignment – which should refelct similarity of EA methods to overcome complexities in organisations;
2. Agility – reflects the change mangement ability of organisations and lastly; and
3. Assurance reflects control in organisations and all the resources needed for products and services delivery.

Schekkerman (2011b) agrees that using EA for business-IT alignment produces an agile working environment. Wang *et al.* (2008) describes EA as a practical and theoretical methodology which can describe how IT can support the organisational operations which can in turn provide business benefits. This confirms the study by Saat *et al.* (2010) who uses the as-is situation of describing business-IT alignment and proposes a practical example using meta models to support business-IT alignment.

The business-IT alignment model proposed by Speshock (2010) can be adapted to incorporate the elements for aligning IT with environmental sustainability strategy and organisational strategy (Figure 2-7). The components of environmental sustainability strategy in the three levels of an organisation (strategic, operational and technological) were therefore identified. The first component is the sustainability reporting objectives for an organisation which need to be considered when embarking on green initiatives (Section 2.2). The second component is the potential benefits of environmental sustainability which also need to be considered (Section 2.3) and the last component is the consideration of risks or challenges faced by organisations when embarking on environmental sustainability intitiatives (Section 2.4).

Two primary challenges of environmental sustainability reporting and feedback to stakeholders, are the complexities of compliance and standardisation (Section 2.5) as well as the tools and technologies available (Section 2.6). In order to improve decision-making, quality environmental information has to be available (Section 2.7). The information requirements and design of information stores must be aligned with the strategic direction of an organisation in order to achieve business-IT alignment and to improve the chances of success of EIM projects (Section 2.8). Similarly the technologies selected in an organisation must be aligned with the operational and strategic components of the organisation. The three components (benefits, challenges and objectives) of the proposed Environmental Sustainability Reporting Component Model are thus mapped onto the alignment elements identified by Speshock (2010) namely, mission, work processes, decisions, information and technology.

The eight objectives most commonly reported in literature (Section 2.2) are classified according to the organisational levels. Similarly the thirteen benefits of sustainability reporting (Table 2-1) are also classified according to the three organisational levels. The third column represents the third component which must be considered when setting a sustainability strategy, and that is the challenges and risks of sustainability reporting (Table 2-2).

ENVIRONMENTAL SUSTAINABILITY REPORTING COMPONENT MODEL

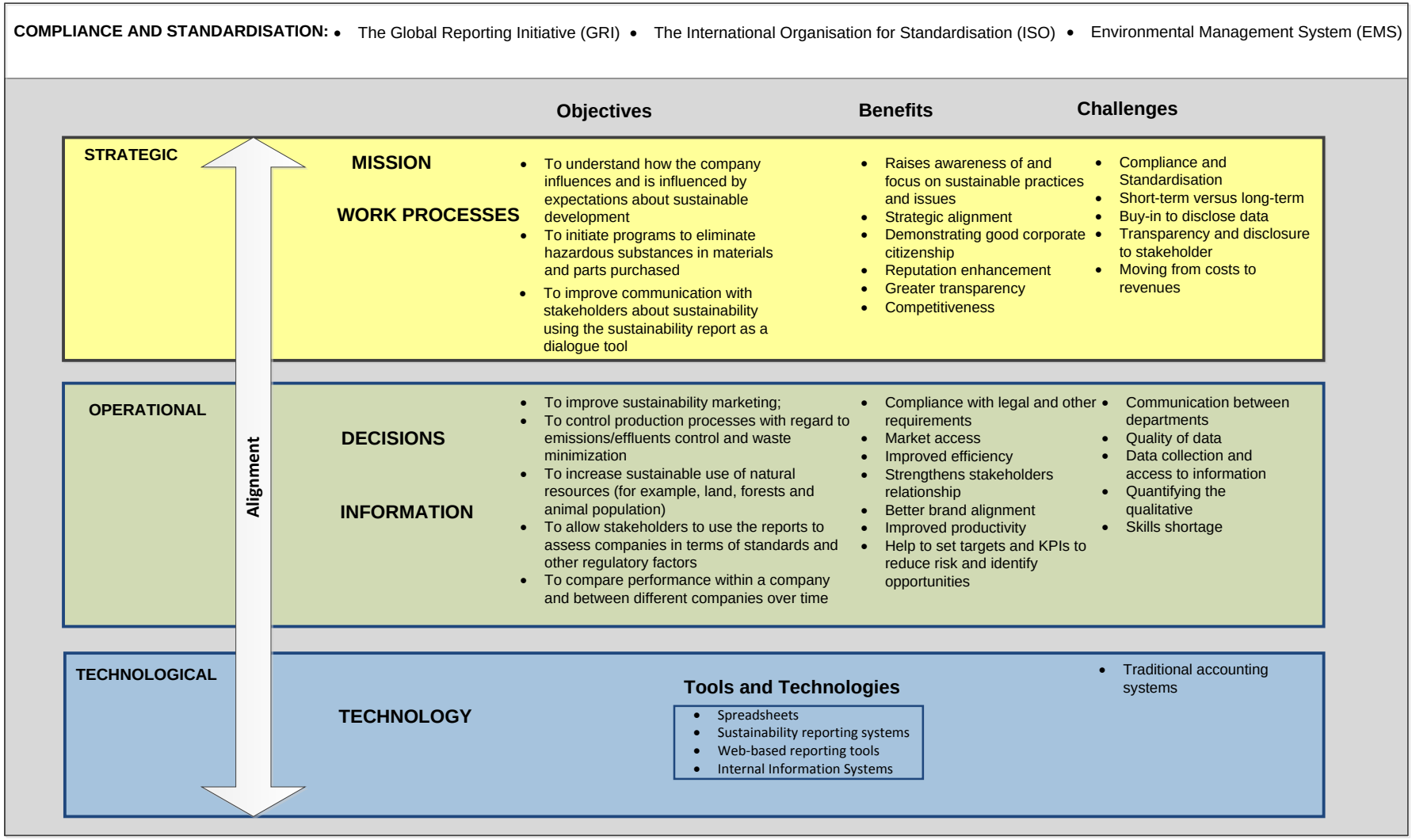


Figure 2-7: Environmental Sustainability Reporting Component Model

2.9 Conclusions

A global need for improved environmental and sustainability reporting is evident. The purpose of this chapter was to answer the first research question (RQ1), relating to the status of environmental and sustainability reporting in organisations.

The main objective for sustainability reporting is for organisations to communicate with stakeholders. Communication is also directly linked to the transparency of an environmental sustainability report as organisations have to disclose environmental sustainability information accurately to stakeholders. Strategic alignment of the environmental sustainability strategies to the IT strategies and to the organisational strategies was identified as an important factor of success.

Compliance and standardisation are a primary challenges for environmental sustainability reporting found in many studies. Organisations struggle to comply with the many mandatory and voluntary standards and legislations which exist. Other challenges relate to the quality of information and the silos found in information systems containing environmental sustainability information, which often cause environmental sustainability reporting to be a daunting process for many organisations. One of the reasons for this was that the environmental sustainability strategies are not aligned to the organisation's strategies and that the environmental sustainability reporting process is seen as a silo process in organisations.

The tools and IT that should support the environmental sustainability reporting process are also not being effectively utilised and are not aligned with strategic objectives. Business-IT strategic alignment is proposed for successful environmental sustainability reporting (Figure 2-7). The environmental sustainability reporting elements are identified in this chapter which form part of the environmental sustainability reporting process including alignment of the business strategies and IT strategies (Figure 2-7). IT resources, systems and tools can assist with the environmental reporting process and the provision of quality of information. Several studies have proposed EA for business-IT alignment. Architectures for environmental reporting have also been proposed but these are often not incorporated in the organisational strategy. The next chapter will investigate EA as a possible solution for business-IT alignment and for improving the process of environmental sustainability reporting.

Chapter 3 Enterprise Architecture

3.1 Introduction

In Chapter 2 several challenges regarding environmental sustainability were highlighted. One of the key uses of Enterprise Architecture (EA) is for business-Information Technology (IT) alignment therefore it can also be used for aligning business and environmental sustainability with IT. EA was first proposed and used by John Zachman during 1987 but was restricted to the field of information systems (Zachman, 1987). A steady increase in the interest of EA is now evident (Magoulas *et al.*, 2012). Since then the concept has evolved to include the enterprise as a whole, and is now being interpreted by academia, the public and private sectors. Many interpretations and definitions exist for EA and the definition that will be used for the purpose of this research is: "*The fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution*" (ISO/IEC/IEEE, 2011, p. 2).

EA is also used as a plan that describes building a system or a set of systems. The architectural designs for systems such as Environmental Management Information Systems (EMIS) are still not extensively supported today and one of the reasons for this is described by El-Gayar and Fritz (2006) as the lack of research for EMIS from the Information Systems (IS) community. A recent study by Aldea *et al.* (2013) show that there is a lack of models to support the strategic alignment and strategic decision-making in organisations. These issues, namely, a lack of research for EMIS and a lack of models' support for strategic alignment contribute to organisations facing environmental concerns and not having the systems and models in place to support environmental data and management in their organisations.

This chapter will investigate the status of EA in organisations. This will be achieved by focusing on two areas. Firstly the objectives, benefits and challenges of EA in organisations. Secondly in terms of the frameworks, tools and technologies for EA design.

The two research questions that will be addressed in this chapter are research question two (RQ2) namely, "*What are the objectives, benefits and challenges of Enterprise Architecture adoption in organisations?"* and research question three (RQ3) namely, "*What frameworks, tools and technologies are adopted for Enterprise Architecture in organisations?"*. The chapter structure (Figure 3-1) illustrates the different sections and sub-sections in this chapter. A comparison between some commonly used EAs in organisations today will be provided (Section 3.2). Several objectives for adopting EA in organisations have been identified (Section 3.3).

The adoption of EA can result in many potential benefits to organisations (Section 3.4). However EA adoption is often accompanied by various challenges (Section 3.5). Organisations use models and modelling notations to achieve their optimal EA (Section 3.6). There are different technology strategies which can support the modelling of EA (Section 3.7). Several architectures for environmental and sustainability reporting have been proposed (Section 3.8). The most common four EA components are Business Architecture, Information Architecture, Application Architecture and Technology Architecture and all the components and elements (objectives, benefits, challenges, tools and technologies) can be mapped on to the EA components and a model is proposed (Section 3.9). An EA can be used for supporting IT and business (including EIM) therefore an EA for EIM Toolkit (Version 1) is proposed (Section 3.10). Several conclusions can be made for EA and for EIM (Section 3.11).

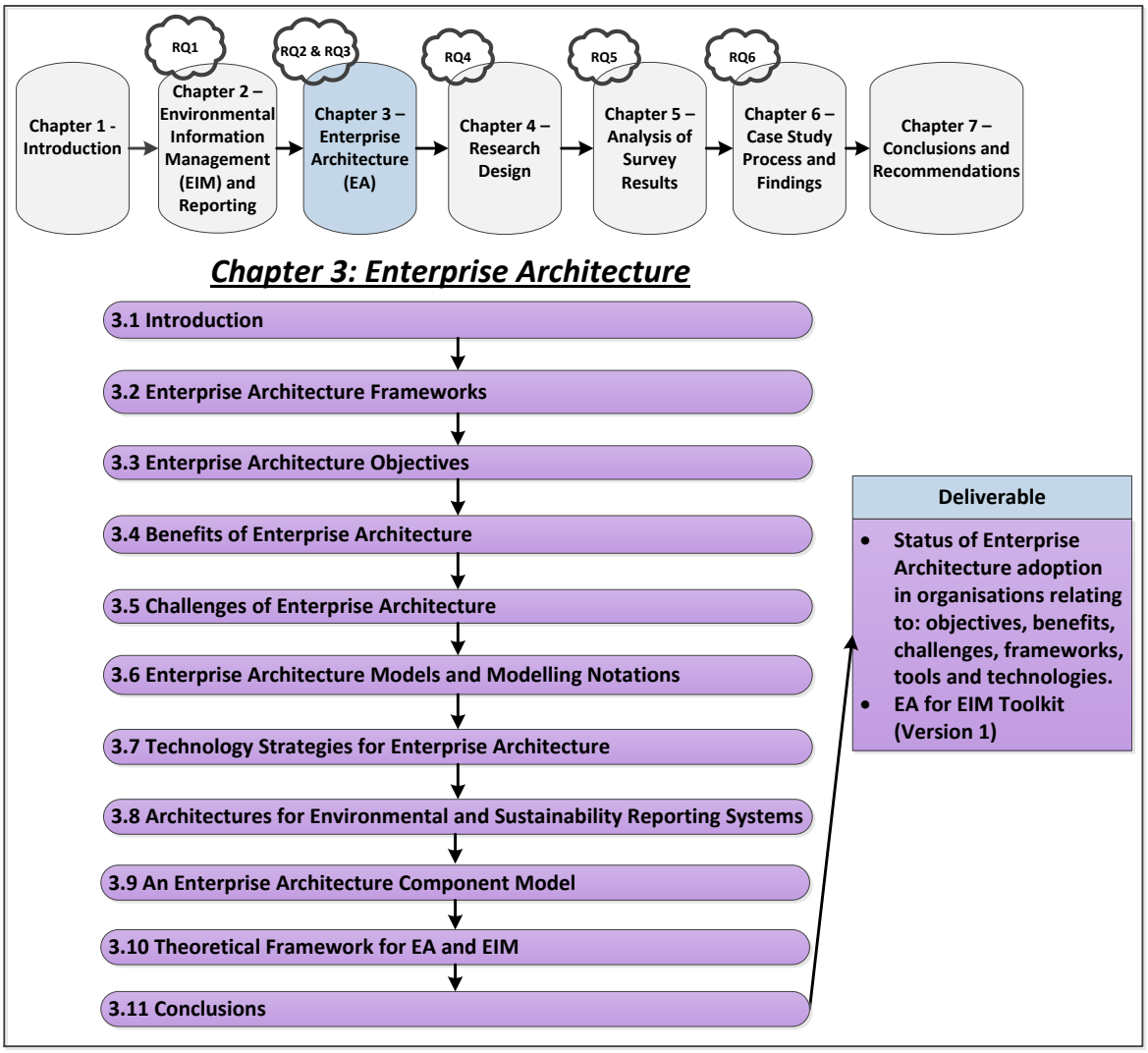


Figure 3-1: Chapter 3 Structure

3.2 Enterprise Architecture Frameworks

The three most commonly used EAs today are the Zachman Framework, The Open Group Architecture Framework (TOGAF), and the Federal Enterprise Architecture Framework (FEAF) (Kattenstroth, 2012; Lakhdiss and Bounabat, 2012; Lankhorst, 2009; Lucke, Krell and Lechner, 2010; Magoulas *et al.*, 2012; Sessions, 2007). An EA which is less widely used is the Ministry of Defense Architecture Framework (MODAF) however it is frequently referred to in theory (Franke *et al.*, 2009; Lankhorst, 2009; Urbaczewski and Mrdalj, 2006; Sessions, 2007). The Zachman Architecture Framework is described as a taxonomy rather than a framework, meaning that it is used for the design of documentation, models as well as for specifications (Section 3.2.1). TOGAF is defined as a process (Section 3.2.2), FEAF is described as a methodology for creating an EA (Section 3.2.3), and the MODAF is described as a framework that can be used in both business and battle space (Section 3.2.4). These frameworks can also be used together to build a single EA, therefore using suitable sections of each to build an optimal EA solution, also described as a hybrid EA framework (Section 3.2.5).

3.2.1 The Zachman Framework

The Zachman framework identifies a target audience for example the business owner as well as the issue for which the taxonomy is required for example data or functionality issues (Sessions, 2007). Since 2008, Zachman described his framework as an ontology, meaning it is referred to as a structure and not a process such as a methodology (Zachman, 2008). The framework allows for defining the components of any object. Therefore the framework should be used to create the necessary definition required to describe the EA components. Zachman also said the following: *"It is my opinion that Enterprise Architecture is the determinant of survival in the Information Age"* (Zachman, 2008, p. 1).

The Zachman Architecture Framework is represented as a 6 x 6 matrix (Figure 3-2), where each of the six columns is represented by questions such as: the what, how, where, who, when and why. The rows are represented by six concrete transformations such as: the executive perspective, business management perspective, architect perspective, engineer perspective, technician perspective and the enterprise perspective meaning the user (Zachman, 2008). These transformations and questions within the matrix are used to describe anything that an organisation regards as important, thus a representation of the entire organisation can be shown by using this matrix.

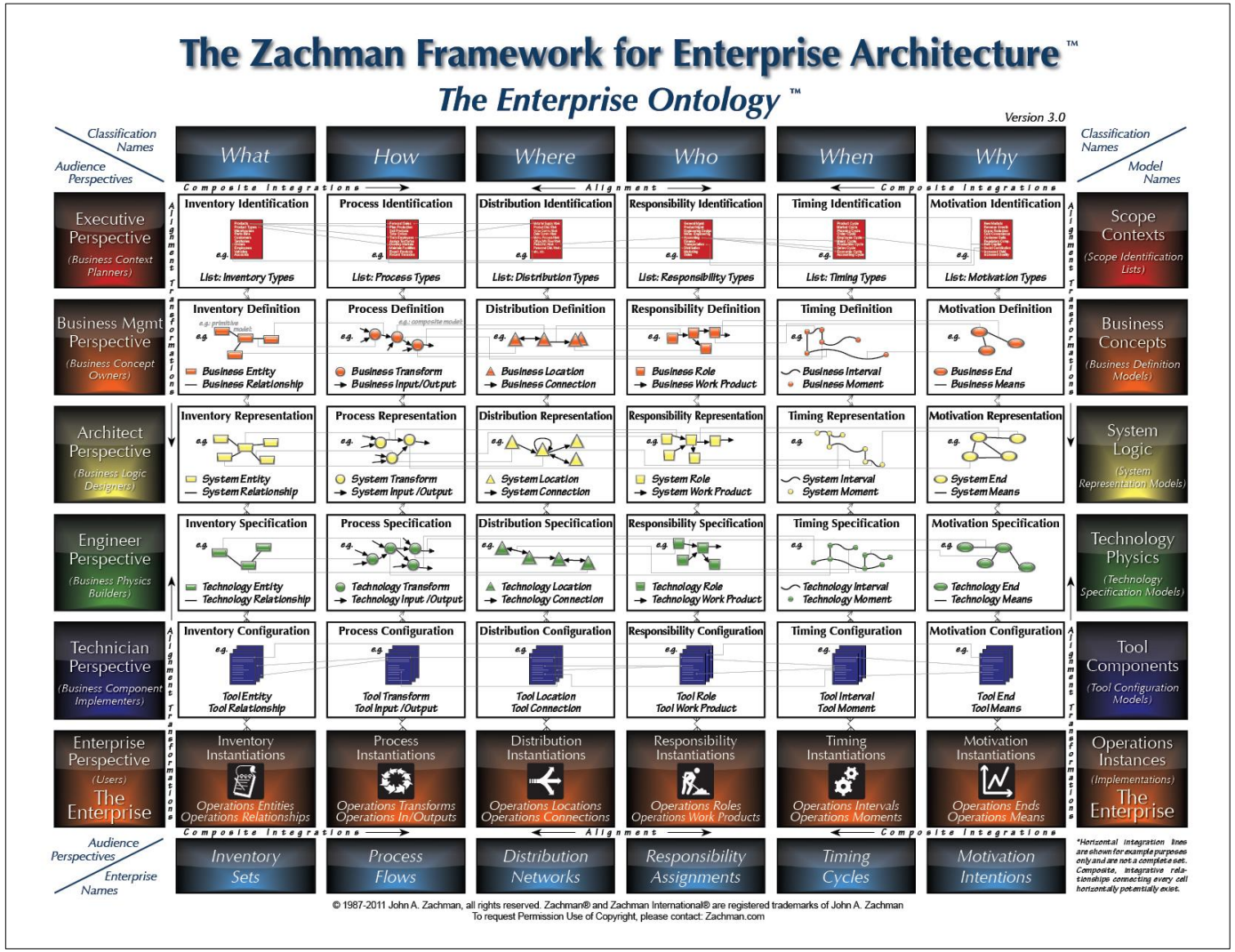


Figure 3-2: Zachman Framework 3.0 (Zachman, 2008)

3.2.2 The Open Group Architecture Framework (TOGAF)

The first version of the TOGAF framework was developed in 1995 by the Open Group and is based on the Technical Architecture Framework for Information Management (TAFIM) also developed by the United States Department of Defense (DoD) (The Open Group, 2009a). The TOGAF framework is regarded as a process that can be used as a method to develop an EA. The development method for TOGAF is known as the Architecture Development Method (ADM), providing guidance on the entire process of developing an EA (Sessions, 2007).

Figure 3-3 illustrates the ADM phases, displaying different architectures using eight phases and a preliminary phase (The Open Group, 2009b). The preliminary phase allows defining an Organisation-Specific Architecture framework and the architecture principles. Phase A represents the Vision Architecture that allows defining the scope of the foundation architecture effort, creating the vision architecture supporting requirements and constraints, and obtaining approvals to proceed.

Phase B represents the Business Architecture that enables developing the detailed business architecture for analysing the gaps results. Phase C is a representation of the Information System Architecture that includes the Information Systems Architectures for an architecture project, including the development of Data and Application Architectures. Phase D, the Technology Architecture for developing a technology infrastructure that is used as a foundation for identifying all components that will support the development, implementation and deployment processes. Phase E includes the Opportunities and Solutions for identifying opportunities and solutions and implementation constraints to deliver a more consistent architecture implementation. Phase F is used for Migration Planning where all work packages and projects can be chosen and prioritised to create, evolve and monitor the detailed implementation and migration plan providing necessary resources to enable the realisation of the transition architectures. Phase G is used for Implementing Governance that provides an architectural oversight of the implementation. Phase H involves Architecture Change Management whereby procedures for managing change to the new architecture can be established. Lastly the Requirement Management Phase is used for managing architecture requirements throughout the ADM.

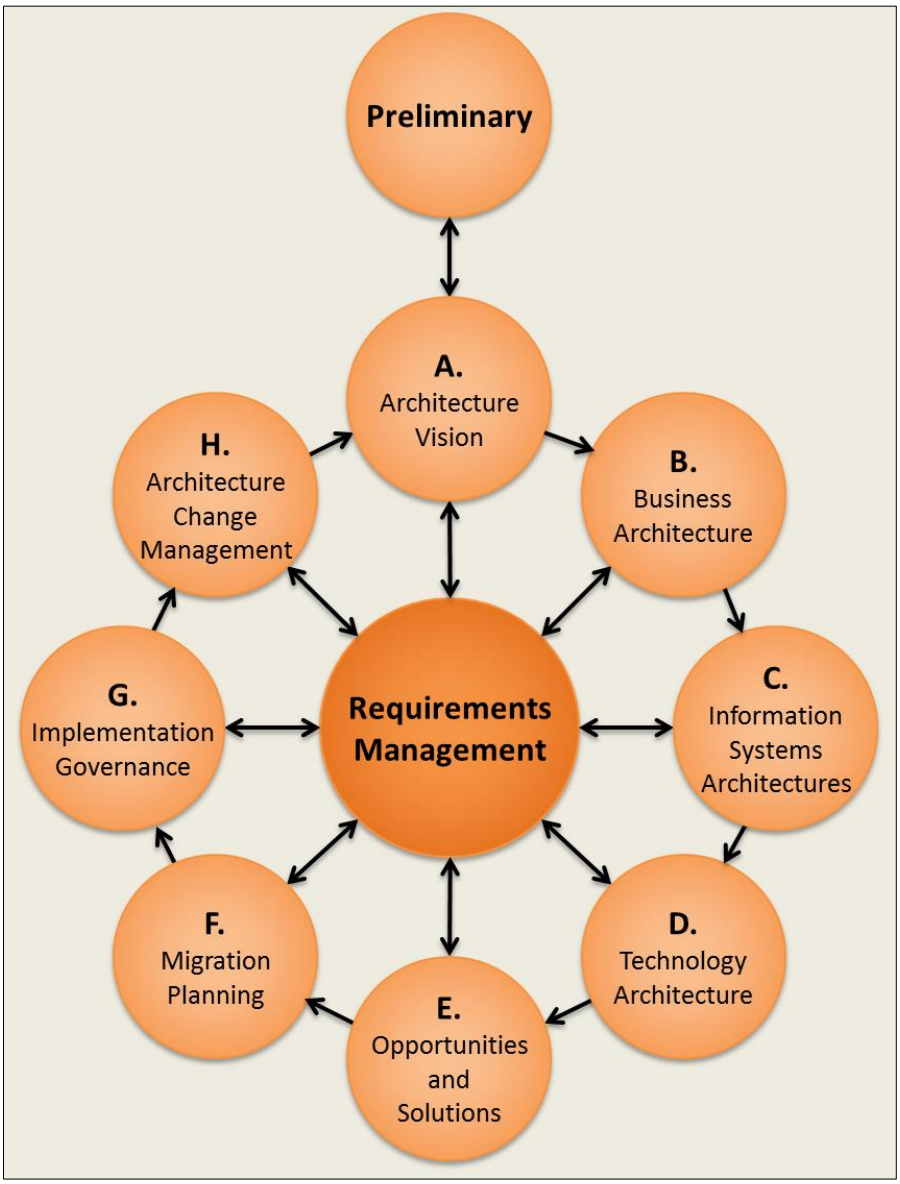


Figure 3-3: The TOGAF ADM Phases (The Open Group, 2009b)

The TOGAF ADM phases refer to four sub-architectures or components of an EA (Sessions, 2007; Taleb and Cherkaoui, 2012). These components are the business, information (or data), application and technology architectures defined by The Open Group (2009b) as:

- **Business architecture** *defines the business strategy, governance, organisation and key business processes.*
- **Data architecture** *describes the structure of an organisation's logical and physical data assets and data management resources.*
- **Application architecture** *provides a blueprint for the deployment of individual application systems, their interactions and their relationships to the core business processes of the organisation.*

- **Technology architecture** *describes the logical software and hardware capabilities that are required to support the deployment of business, data and application services. This includes IT infrastructure, middleware, networks, communications, processing and standards.*

TOGAF has an Architecture Content Framework (Figure 3-4) which provides a detailed model of architectural work products, named the content metamodel (The Open Group, 2009b). These work products include Architecture Building Blocks (ABBs) which are represented by deliverables and artifacts. The content metamodel has five visible ABBs namely:

- The Architecture Principles, Vision and Requirements;
- The Business Architecture;
- The Information Systems Architecture;
- The Technology Architecture; and
- The Architecture Realisation.

A building block is at functionality that can be defined to meet the needs of an organisation. The content metamodel is used to manage concerns such as business services, actors, applications, data entities, and technology (The Open Group, 2009b). These concerns are identified in the content model in order to show their relationships, and artifacts that can be used to represent them in a structured manner. The content metamodel can also be used by organisations as a guide to implement their EA with the aid of an EA tool. The four main components of an EA, namely the Business, Data, Application and Technology Architectures are included in the content metamodel (The Open Group, 2009c). The Preliminary and Architecture Vision which is part of ABBs in the content metamodel is a representation of the first two phases in the ADM (The Open Group, 2009b). The Realisation building block includes Phases E, F and G of the ADM.

Research show that the TOGAF framework is most commonly used amongst South African organisations (RealIRM, 2007). Since 2007 a steady increase amongst large South African organisations adopting the TOGAF framework was evident on a global level. RealIRM (2007) reported that the members of the Architecture Forum globally included 9% of South African members, which is said to be above the traditional average. A recent study by Josey (2013) confirms this, where South Africa is listed seventh globally for the number of TOGAF certifications amongst South African organisations.

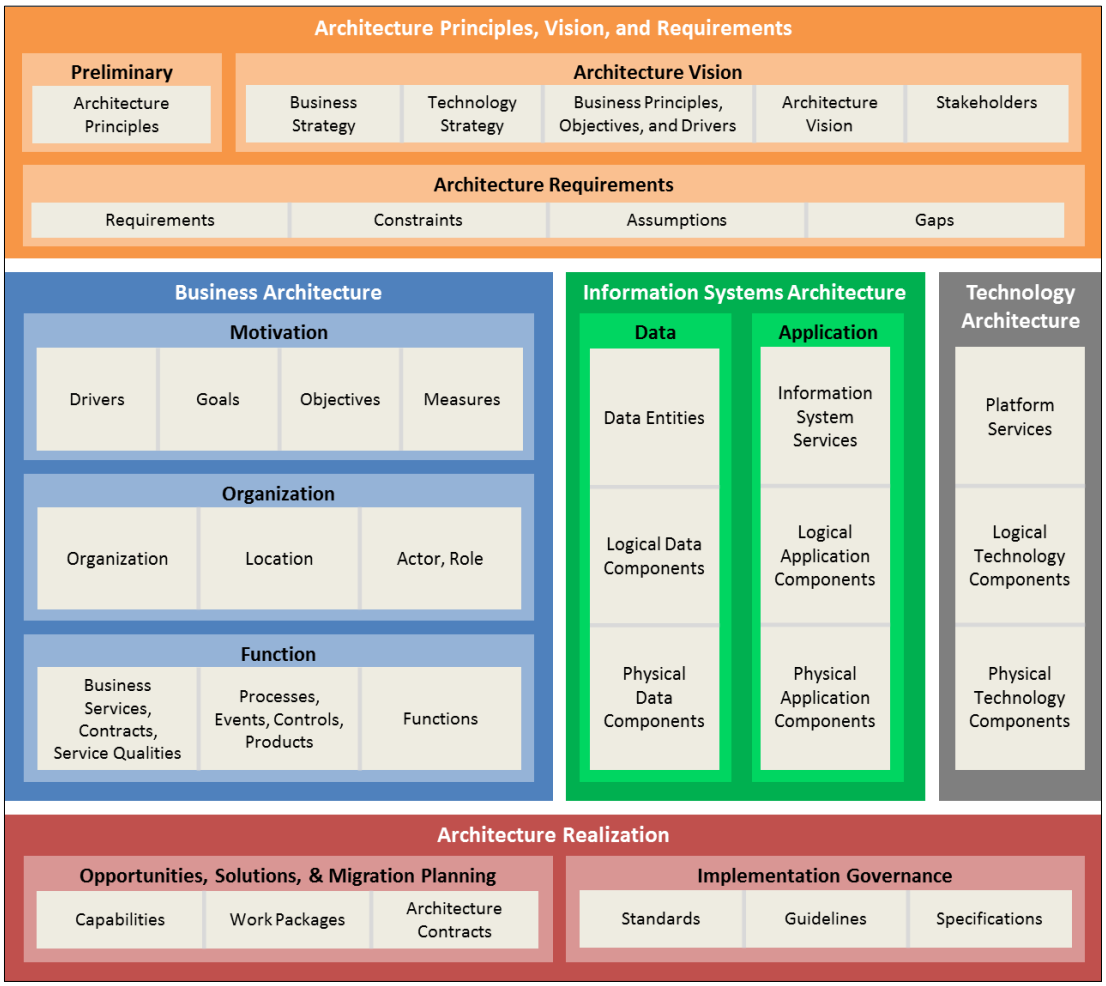


Figure 3-4: TOGAF Content Metamodel (The Open Group, 2009b)

3.2.3 The Federal Enterprise Architecture Framework (FEAF)

The FEAF is used for the developments of uniformity amongst processes and information of government and federal agencies. It is said that the framework can also be used by other organisations, whether profit or non-profit organisations (Akkasi and Shams, 2008). The FEAF was mostly completed in 2006 and therefore is being regarded as a framework that is in its infant stages (Sessions, 2007). The benefit of the FEAF is that it can be used as a methodology or as a structure; therefore it can be seen as a hybrid of both the Zachman framework and the TOGAF framework.

Version 2 of the FEAF is based on a “Common Approach” and was released during 2013 (Federal Enterprise Architecture Framework, 2013). This approach describes the implementation process to government users. The FEAF consists of six sub-architectures referred to as a “Reference Model”.

Figure 3-5 illustrates this reference model and the six sub-architectures namely the Strategy or Performance Reference Model (PRM), Business Reference Model (BRM), Data Reference Model (DRM), Application Reference Model (ARM), Infrastructure Reference Model (IRM) and the Security Reference Model (SRM) architectures. The Consolidated Reference Model (CRM) represented as the FEAF version-2 included the six main components found in the framework. The first component, the PRM allows for the measurement of investments based on the strategic results through linking the agency strategy, internal business components, and investments. The second component is the BRM which focuses on describing common organisational missions and support service areas, therefore enhancing the collaboration between intra (for example Administrators, Business and Senior Executives Managers) and inter (for example Office of Management and Budget) agencies. The DRM is the third component, which allows for data silos to be identified and thus assist in creating the understanding of the meaning of the data found as well as to explain how to access the data in order to support the greater organisational performance.

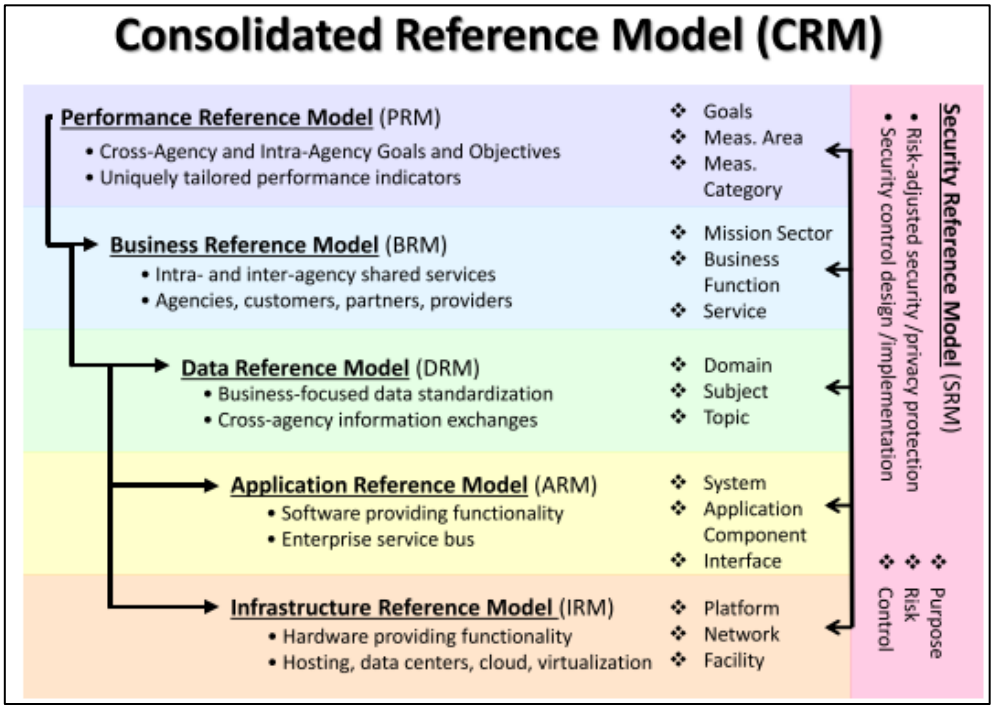


Figure 3-5: Consolidated Reference Model (Federal Enterprise Architecture Framework, 2013)

The fourth component, the ARM, promotes the classification of standards regarding systems, application and technologies which are needed to support service delivery and thus allows the agencies to share and reuse common solutions. The fifth component is the IRM, which classifies the network and/or cloud-related standards and technologies to support and enable the delivery of voice, data, video, and mobile service components and capabilities.

The last component is the SRM which "provides a common language and methodology for discussing security and privacy in the context of federal agencies' business and performance goals" (Federal Enterprise Architecture Framework, 2013, p. 21). The main purpose of these "Reference Models" is to standardise and categorise the strategic, business, and technology models and information. The benefit of standardisation, in this case using a common language to describe investment information, helps with better analysis and reporting practices.

3.2.4 Ministry of Defence Architecture Framework (MODAF)

Version 1.0 of the United Kingdom Ministry of Defence Architecture Framework was released in 2005 (MODAF, 2005). MODAF was created to support the Ministry of Defence processes, acquisitions and capability management tasks. The framework enables the management of complexities in organisations and identifies how to represent an integrated enterprise model. MODAF is divided into three main Architectural Framework (AF) parts (MODAF, 2005). The first AF is "Viewpoints", which cover the operations or business and technology perspectives in an organisation. The second AF is "Meta Models" which allows for the sharing and storing of the architectural information such as the products and tools used for implementation, thus the ability of the reuse of products and its information is allowed. The third AF is "Taxonomies" which is used as a reference for all the terminology of MODAF and thus supports the ability to compare architectures, exchange of data and achieving architectural coherence.

The "Viewpoints" includes four main views: the Business Process View, the Strategy View, the Solution View and the Programme Management View (Bailey, 2008). The Strategic and Service Views identify the standard capabilities and services used for architectures and projects. The Service Viewpoint is new in MODAF version 1.2 released in 2008.

3.2.5 Hybrid Frameworks

Hybrid frameworks have also been proposed which utilise the best of different frameworks (Oracle, 2009, 2012; Egham, 2010). The reason for this is that each framework has benefits, advantages and disadvantages. No single EA framework can provide a "one size fits all" solution.

An Egham (2010) press release described how a shift towards hybrid thinking for EA solutions can help organisations to adopt transformation, innovation and strategy creation. Oracle has produced a hybrid EA framework, the Oracle EA Framework (OEAF), which is based on TOGAF, FEAF and Gartner (Oracle, 2009, 2012).

The OEAF framework (Figure 3-6) includes four main components: Business, Application, Information and Technology architectures. The framework also proposes steps which should be followed to create and maintain an EA. The hybrid solution not only establishes the ability to design an EA based on best-practice EA frameworks, but it also promotes the importance of aligning business strategies to IT strategies and closer collaborations between departments in an organisation (Egham, 2010).

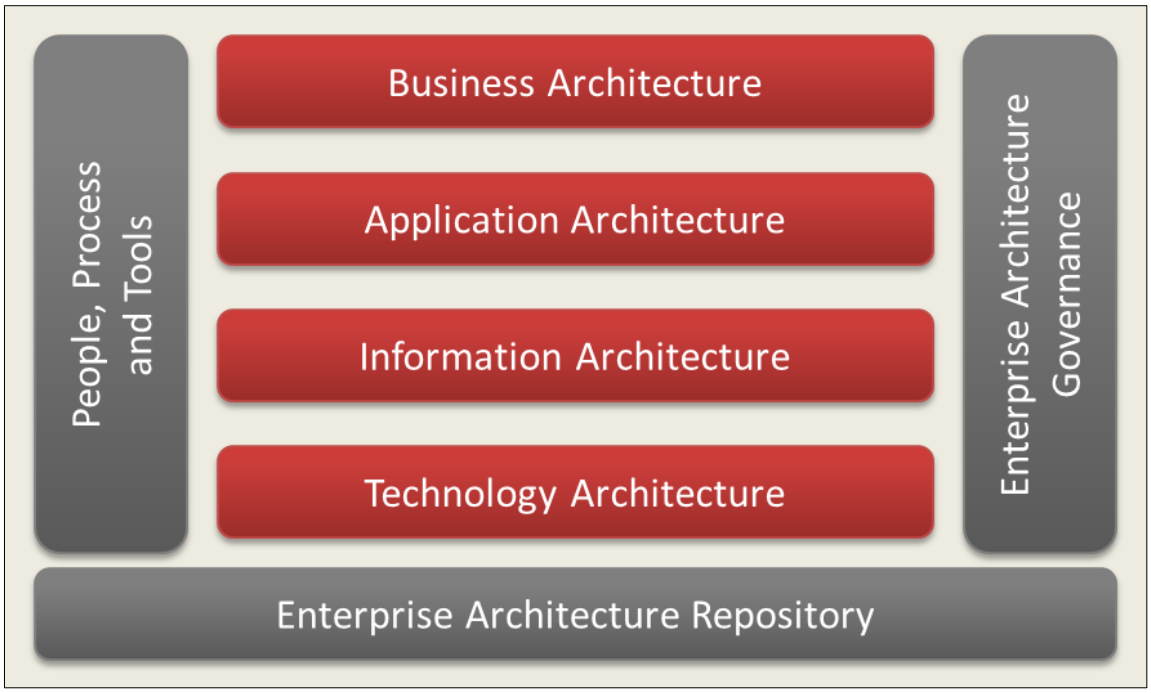


Figure 3-6: Oracle Enterprise Architecture Framework (Oracle, 2009, 2012)

3.3 Enterprise Architecture Objectives

Organisations have different objectives for their EA programmes and the most common objective for EA programme adoption is to support business-IT alignment and system integration (Ambler, 2010; Iyamu, 2011; Magoulas *et al.*, 2012; Schekkerman, 2011a). The organisational objectives can be classified according to the proposed EA components and organisational levels (Table 3-1). The EA Objectives classification model illustrates the organisational objectives according to each of the EA components within an organisation.

Other objectives reported are to improve enterprise decision-making, as an EA is used in decision-making processes and it can be used as a source of information (Ambler, 2010; Chen, Doumeingts and Vernadat, 2008; Schekkerman, 2011b). EA is used to promote business efficiency or transformation.

If an EA is used to achieve the organisational objectives it also allows for the organisational operations to be transformed in order to achieve efficiency within the operations (Ambler, 2010; Lange and Mendling, 2011). EA is used to ensure continuity of organisational knowledge for future workers and future process management. It is required that the knowledge should be captured for future use and for decision-making purposes (Ambler, 2010; Chen *et al*., 2008; Magoulas *et al*., 2012).

EA is used to reduce operating costs such as IT related costs, when managers need to decide which IT products to buy or to terminate and the cost of running the organisational processes such as producing new products, services and maintenance cost (Ambler, 2010; Lange and Mendling, 2011; Winter and Schelp, 2008). EA can be used to improve environmental concerns as it can specify information about environmental compliance, environmental changes and technologies which can assist in the tasks of Environmental Information Management (EIM) (Ambler, 2010; Gravesen, 2012). EA can be used to support outsourcing initiatives, as it can manage and specify all in-house and outsourced applications within the application architecture component (Ambler, 2010; Sims, 2005).

EA improves IT governance as an EA should contain the decision rights of how IT should be used appropriately within the organisation and for improving the organisational processes (Ambler, 2010; Winter and Schelp, 2008). EA improves data integrity as it can assist with specifying the data handling, what the data is used for and how the data in the organisation is represented (Ambler, 2010; Sims, 2005). EA improves risk management, since an EA should clearly stipulate any risks from a business and IT perspective (Ambler, 2010; Chen *et al.*, 2008; Lange and Mendling, 2011).

EA increases effectiveness of organisational compliance if aspects related to the organisations, such as regulations, market laws as well as data and process ownership are specified and described (Ambler, 2010; Lange and Mendling, 2011; Winter and Schelp, 2008). EA is used to improve technical integrity as security of information and transactions in organisations is a major concern and the EA specifies the integrity measures that organisations should use (Ambler, 2010; Sims, 2005).

Table 3-1: EA Objectives Classification Model

Organisational levels of processes	EA Component	EA Objectives	Reference
Strategic	**Business Architecture**	To improve enterprise decision-making	Ambler (2010) Chen *et al.*(2008) Schekkerman (2011b)
		To promote business efficiency or transformation	Ambler (2010) Lange and Mendling (2011)
		To ensure continuity of organisational knowledge	Ambler (2010) Chen *et al.*(2008) Magoulas *et al.* (2012)
		To reduce operating costs	Ambler (2010) Lange and Mendling (2011) Winter and Schelp (2008)
		To improve environmental concerns	Ambler (2010) Gravesen (2012)
		To support outsourcing initiatives	Ambler (2010) Sims (2005)
Operational	**Information Architecture** **Application Architecture**	To improve IT governance	Ambler (2010) Winter and Schelp (2008)
		To improve data integrity	Ambler (2010) Sims (2005)
		To improve risk management	Ambler (2010) Chen *et al.*(2008) Lange and Mendling (2011)
		To increase effectiveness of organisational compliance	Ambler (2010) Lange and Mendling (2011) Winter and Schelp (2008)
Technology	**Technology Architecture**	To improve technical integrity	Ambler (2010) Sims (2005)
		To promote a common technical infrastructure	
		To reduce technical complexity	Ambler (2010) Sims (2005) Winter and Schelp (2008)
		To support system integration	Ambler (2010) Iyamu (2011) Magoulas *et al.* (2012) Schekkerman (2011a)

EA is used to promote a common technical infrastructure where the EA should be able to simplify the technical infrastructure in organisations for all users involved in processes such as developmental projects and/or for the use by project managers (Ambler, 2010; Sims, 2005). To reduce technical complexity is a major objective for many organisations that use EA. These complexities mainly evolve when no alignment exists between the business and IT. It is said that enterprise architects mainly focus on this alignment issue in organisations (Ambler, 2010; Sims, 2005; Winter and Schelp, 2008).

3.4 Benefits of Enterprise Architecture

Research studies indicate several benefits for EA programme adoption, and these benefits can be grouped according to the three levels of processes in an organisation (Table 3-2). The EA benefits at the strategic level are business governance, business efficiency, risk management and continuity of organisation knowledge. The benefits of EA adoption should be considered prior to adoption as part of a Return on Investment (ROI) analysis.

Table 3-2: Benefits of EA Programme Adoption

Organisational levels of processes	Benefits	References
Strategic Benefits	Business governance	Gravesen (2012) Winter and Schelp (2008)
	Business efficiency	Ross (2006)
	Risk management	Chen *et al.* (2008) Lange and Mendling (2011) Ross (2006)
	Continuity of organisation knowledge	Chen *et al* (2008) Magoulas *et al* (2012)
Operational Benefits	System integration	Chen *et al.* (2008)
	Data integrity	
	IT governance	Gravesen (2012) Winter and Schelp (2008)
	Audit compliance	Ross (2006)
Technology Benefits	Technical integrity	Chen *et al.* (2008)
	Team follows a technical infrastructure	Ross (2006)

Clear and effective business governance can contribute to consistent and appropriate EA process outputs (Gravesen, 2012; Winter and Schelp, 2008). Strong governance also makes it easy to manage the initiatives of an EA and reduces the need to change the structure of an organisation. Business efficiency can be achieved through the value that can be gained through the IT and operational capabilities in an organisation (Ross, 2006). EA provides organisations with the ability to reduce their IT risks such as reduced security breaches and increase disaster tolerance since it is easier and faster to attain backup and recovery services (Chen *et al.*, 2008; Lange and Mendling, 2011; Ross, 2006).

The benefits at the operational level are system integration, IT governance, data integrity and audit compliance. With EA the transfer of knowledge is made easier especially regarding applications and integration of technologies (Chen *et al.*, 2008; Magoulas *et al*., 2012). EA allows systems integration not to be isolated but to take into account the business perspective (Chen *et al.*, 2008). Having information in an organisation integrated in one place such as the EA enhances data integrity (Chen *et al.*, 2008).

EA creates a platform for IT governance to become quite established in terms of translating the functions of IS and IT to the organisational functions (Gravesen, 2012; Winter and Schelp, 2008). EA allows for early audit compliance reviews of all projects (Ross, 2006). Technical integrity and the willingness of technical infrastructure adoption by team members on EA projects are the benefits experienced at a technology level. Technical integrity is achieved with an EA as it allows for continuous testing of all prototype projects to ensure technical and conceptual integrity (Chen *et al.*, 2008). Another benefit of EA is that the team has a standardised technical infrastructure to follow (Ross, 2006).

3.5 Challenges of Enterprise Architecture

The challenges of EA can be grouped according to the three levels of processes in an organisation (Table 3-3). The challenges that have been identified at a strategic level are capacity, diversity, relevance, management and semantic problems. Coordination, rigidity and representation were the challenges identified at an operational level. Insufficient resources and complexity were the two main challenges identified at a technological level.

A challenge which has always been prevalent in organisations is that of the alignment of organisational processes and structures, which indicates the issues of business-IT alignment (Ritter, 2007; Wang *et al.*, 2008). EA complexity is also a commonly identified challenge, in many cases because environmental influences and growth in terms of organisations expanding its business sectors (Gravesen, 2012; Lucke *et al.*, 2010). Gravesen (2012) reports several challenges encountered with EA adoption such as capacity, as the resource capacity constraints on EA can lead to many other challenges such as resistance to EA and lack of integration. Diversity is a challenge which refers to an organisation responding either negatively or positively to using EA in order to standardise and integrate diversities within the organisation. Coordination is a challenge which involves networking with other organisations to address external and internal networking influences. Relevance is a challenge for organisations to firstly find the need for EA and then identify the relevance for EA in an organisation. Rigidity is known as the ripple effect challenge which occurs when organisations have joint business ventures and or functions, since changing one aspect can affect the entire structure or unit for all parties involved.

Lucke *et al*. (2010) propose five main challenges of EA adoption. The management challenge includes issues such as management commitment, EA governance, stakeholder concerns and coordination. The semantic problems challenge includes issues such as communication, understanding requirements and shared understanding.

Insufficient resources is a category that involves issues regarding lack of experienced architects. The complexity challenge refers to issues about rapidly changing conditions, checking architectural descriptions and EA frameworks. Representation is a category that involves issues such as EA frameworks, knowledge management and insufficient tool support.

Table 3-3: Challenges of EA Programme Adoption

Organisational levels of processes	Challenges	References
Strategic Challenges	Capacity	Gravesen (2012)
	Diversity	
	Relevance	
	Management	Lucke *et al.* (2010)
	Semantic problems	
Operational Challenges	Coordination	Gravesen (2012)
	Rigidity	
	Representation	Lucke *et al.* (2010)
Technology Challenges	Insufficient resources	
	Complexity	

3.6 Enterprise Architecture Models and Modelling Notations

Methods exist to decrease the complexities in both business and IT and thus to overcome the challenges of IT and business alignment (Kattenstroth, 2012). Kattenstroth (2012) illustrates how Enterprise Modelling (EM) and EA management can assist in the task of reducing the complexities in IT management, business management and in the development of large information systems. Orr, Roth and Nelson (2004) also agree that EA modeling can assist organisations to respond faster to critical market changes. Orr *et al.* (2004) also state that how quickly organisations respond to these market changes is usually directly linked to well managed business and IT assets and infrastructures. EA is represented through models (Table 3-4) and uses modelling notations also referred to as modelling languages, in order to give organisations a holistic view of their business processes, applications, services, information and technologies (Kattenstroth, 2012; Iyamu, 2011; McLeod, 2009).

Table 3-4: EA Models

Models	References
Business architecture model	Orr *et al.* (2004)
Component model	IBM (2005) Sparx Systems (2004)
Detailed Enterprise Data Model (EDM)	EDM TEAM (2011)
Enterprise Business Process Model	Alexopoulou, Nikolaidou and Anagnostopoulos (2010)
Enterprise Use Case model	Sparx Systems (2010) Object Management Group (2009)
High-level conceptual data model	Gemino and Wand (2004)
Security models	Ekstedt and Sommestad (2009)

The business architecture model can represent the organisation as a whole in terms of its strategies, business, data, information, application and technology architectures (Orr *et al.*, 2005). The Component model can be used to represent the software components which are needed to model the EA (IBM, 2005; Sparx Systems, 2004). The component model from a business point of view can be used to represent a specialised focus for EA, whether to represent an internal or external focus of an organisation. The Detailed Enterprise Data Model (EDM) serves as a repository that includes all the data of an organisation in a logical manner (EDM TEAM, 2011). It should define and label the data concepts and elements as well as their relationships. The EDM model should also contain all the business rules for their data.

The Enterprise Business Process Model consists of different structural elements such as activities, data, events and roles of an organisation (Alexopoulou *et al.*, 2010). Several studies show that the Unified Modelling Language (UML) consists of language units for different modelling concepts (Matthes, 2011; Object Management Group, 2009). These studies also show that the users should only be concerned about the language units of interest to the models that they want to create. The UML Use Case diagrams are also quite popular for creating EA models. The Enterprise Use Case model is a UML element which consists of a collection of use cases which are included in a model or diagram also known as the Use Case diagram (Object Management Group, 2009). The Use Case diagram represents the objectives and requirements of a system or a scenario. The purpose of the high-level conceptual data model is that it is categorised to describe a domain in terms of understanding, reasoning, communicating, and documenting the domain information for future reference (Gemino and Wand, 2004). Some of the EA security models that have been identified in the research field are the Zachman framework, the Department of Defense Architecture Framework (DoDAF) and the TOGAF (Ekstedt and Sommestad, 2009). The secure UML has also been recognised as a language that is used to design security models.

Several EA languages and notations are used in an EA (Table 3-5). Archimate is a well-known EA modelling language which is based on the UML standard (Schekkerman, 2011a; Lankhorst, 2009). Archimate has become known as the standard modelling notation to be used with the TOGAF framework, as its main purpose is to define cross-domain relations. It allows for easy mapping of the three ADM architectures, namely, business, information systems, and the technology architectures found in TOGAF to those, business, application, technology architectures found in Archimate (Lankhorst, 2009). Therefore Archimate is also used for the challenge of aligning the business and IT strategies (Schekkerman, 2011a).

Integration DEFinition (IDEF) is another referenced EA modelling language (Schekkerman, 2011a; Lankhorst, 2009). IDEF was developed by the United States (US) Ministry of Defence and consist of 16 modelling techniques.

Table 3-5: Modelling Notations

Modelling Notation	References
Unified Modelling Language (UML)	Matthes (2011) Object Management Group (2009)
Domain-specific modelling language	Kattenstroth (2012) McLeod (2009)
Business Process Modelling Notation (BPMN)	Flowers and Edeki (2013)

Domain-specific modelling languages enable the ability to create homegrown definitions and thus support the ability to capture, maintain, query, analyse and output the EA elements specific to the organisation (Kattenstroth, 2012; McLeod, 2009). The Business Process Modelling Notation (BPMN) is used to help organisations to better understand their internal business processes through the classification of the information about their business processes (White, 2004). Examples of the graphical elements of the BPMN are the flow objects, connection objects, swim-lanes and artifacts.

Frequently used EA models (Table 3-4) and the EA modelling notations (Table 3-5) were identified and will be included later in the survey study for this research. The next section will identify and describe the technology strategies for EA used in organisations.

3.7 Technology Strategies for Enterprise Architecture

EA is part of a larger technological and information age era (Zachman, 2008), and it is for this reason that the importance of the technology strategies which support the development of EA in general, are important (Table 3-6). These technology strategies range from Business Process Management (BPM), Service Oriented Architecture (SOA) to Product Line Architecture strategies (Ambler, 2010).

BPM is seen as a management discipline which guards the way of thinking in terms of aligning the internal and external business process performance but also includes BPM technology which can be incorporated in an organisation's EA to achieve better business operations (Bandara *et al.*, 2005; Jensen *et al.*, 2011). The understanding of documenting the business processes allows for measuring, monitoring and controlling the performance of the business processes.

BPM also allows constantly designing and improving the business processes so that they can meet the demands and expectations of customers. Therefore it is intended to lead to achieving organisational objectives, such as cost, revenue and cycle time.

Spence, Devoys and Chahal (2009) report that Software as a Service (SAAS) is one of the categories of cloud computing and is regarded as the most mature category in terms of software hosting. The concept of SAAS is for the organisation to rent the software applications needed instead of purchasing, therefore providing a more cost effective option. SOA is used to describe templates and patterns and is also a guideline for aligning business services (Skalle and Hahn, 2013). A service in this case is a software resource or a function which is coded by using application programming interfaces (APIs).

SOA is used to create reusable building blocks which represent smaller sets of business processes and these processes can be assembled as needed. SOA is also seen as a more cost effective choice for the design of models such as EA models. Cloud Computing is an IT resource which is defined by the National Institute of Standards and Technology as: "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*" (Mell and Grance, 2011, p. 2). Product Line Architecture is used to create a reference architecture for a set of related products (Baker *et al.*, 2013).

Table 3-6: EA Technology Strategies

Technology strategy	Reference
Business Process Management (BPM)	Jensen *et al.* (2011)
Software as a Service (SAAS)	Spence *et al.* (2009)
Software Oriented Architecture (SOA)	Skalle and Hahn (2013)
Cloud Computing	Mell and Grance (2011)
Product Line Architecture	Baker *et al.* (2013)

3.8 Architectures for Environmental and Sustainability Reporting Systems

Chachage *et al*. (2006) emphasise the importance of having appropriate systems in place for the management of sustainability information and to simplify the process of extracting and recording sustainability information. Therefore, in order to have an appropriate management system in place it also requires the investigation of the Information Architecture support for environmental sustainability information.

Several architectures for environmental and sustainability reporting have been proposed (Athanasiadis, 2006; Cislaghi *et al.*, 2006; Solsbach *et al.*, 2011). Some of these are management models, whilst others are more technical reference architectures. One of these architectures is the Environmental Enterprise Service Provider (E2SP) architecture (Figure 3-7), which is also described as an Application Service Provider (ASP) model and has the ability to do online reporting and forecasting (Cislaghi *et al.*, 2006). The E2SP-model is said to be a "single access point" for the environmental information requirements and supports decision-making to environmental agencies in an online manner.

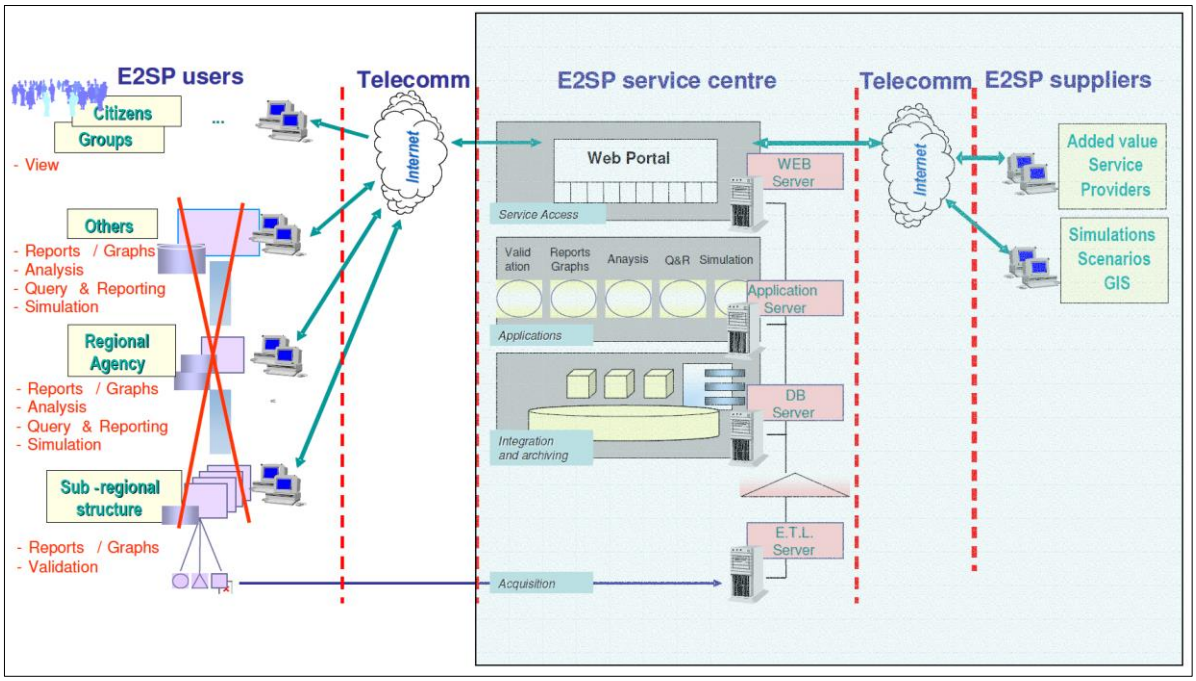


Figure 3-7: The E2SP Service Centre Architecture and the Users (Cislaghi et al., 2006)

Athanasiadis and Mitkas (2004) propose a systems architecture which includes agents that are grouped in three layers namely: contribution, management, and distribution agents. Information flows from the left side of the systems architecture to the users on the right side via three agent layers. An example of the information flow is when measurements of air-quality reach the system from the sensors, and then the Diagnosis agents have to capture the information When the information is validated it is then delivered to the Alarm agent in the Management layer. The information is also stored in the database for future use by the database Agent. The Alarm agent thus determines whether a formal alarm or a custom alarm should be sent based on the validated measurements. Formal alarms represent dangerous situations imposed by the law.

The custom alarms are indications of the system users concerns. Certain alarms are then delivered to the Distribution Agent who is responsible for delivering the information to the end users in the correct format.

The Sustainable Online Reporting Model (STORM) system (Figure 3-8) includes a retrieval technique using a three part reference architecture (Solsbach *et al.*, 2011). The middle part of the architecture contains the internal systems of an organisation, the top part is the part for the website whereby the public is allowed to view sustainability reports made available to the public. The lower part of the architecture consists of the external systems.

The component of STORM that is responsible for the data exchange and retrieval is the schema. Solsbach *et al*. (2011, p. 4) refer to a schema as an *"abstract representation or definition of all content and guidelines a report has to follow"*. A schema in this case could be the GRI G4-guidelines. The schema would than contain environmental indicators and all the relevant data that describe an indicator and the data retrieval technique to be followed. The reference architecture allows for data interfaces to be defined for the indicators. These interfaces will allow for information to be automatically retrieved from the external systems in the lower part or exported to the external systems. When the data is retrieved it is stored internally in the middle part of the STORM database.

When all the information in STORM is gathered and the environmental report is produced it can then be made available on the organisation's web site for stakeholders to view or download. If an organisation follows transparent reporting to stakeholders they can make use of the additional Web 2.0 functionalities. The functionalities can enhance communication with stakeholders through social communities and feedback control modules being added to the reference architecture. The STORM reference architecture can handle environmental information and reporting capabilities. It also has the capability to be integrated into an IS of an organisation.

The Climate and Lake Impacts in Europe (CLIME) architecture is part of a project that studies the environmental problem that has an impact on the lakes and the impact that these changes has on society (Jolma *et al.*, 2005). The architecture also includes future aspects such as a Decision Support System (DSS) for end users. The CLIME DSS architecture is at the highest level of a network which includes a four node chain. The data produced by the offline node is stored in the database node. Users access information from the database via the online node. The architecture presents a generic solution to the problem of how knowledge is being transferred.

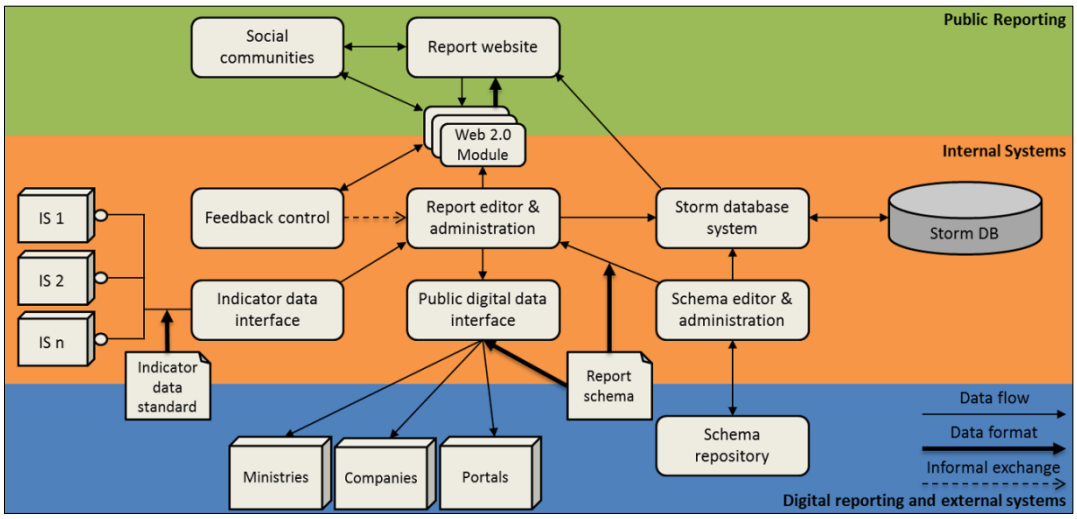


Figure 3-8: Reference Architecture for Sustainability Reporting (Solsbach *et al.*, 2011)

An environmental product information system is proposed by Miyamoto and Fujimoto (2002) to help individuals cope with their day-to-day information requirements to complete their environmentally aware activities. An analysis of several architectures revealed that an EMIS should be able to accommodate the following features in order to support environmental information and reporting capabilities:

- Support for Web 2.0 (Solsbach *et al.*, 2011);
- Provide online real time access to environmental sustainability information (Solsbach *et al.*, 2011);
- Allow stakeholder dialogue (Solsbach *et al.*, 2011);
- Support integration of the EMIS with operational systems and databases (store, access, retrieve, present) (El-Gayar and Fritz, 2006; Solsbach *et al.*, 2011); and
- Allows reporting which adheres to standard reporting and compliance (GRI, 2013a; SAICA, 2009).

Organisations can use the proposed EA components model described in the next section to clearly identify their EA objectives. These objectives can be mapped to each of the elements for each component and at the appropriate organisational level. This can also include the EMIS features which can enhance the alignment of the environmental sustainability and the EA objectives throughout an organisation.

3.9 An Enterprise Architecture Components Model

The business-IT alignment model proposed by Speshock (2010) is extended to incorporate the use of EA for business-IT alignment into an EA Components Model (Figure 3-9). The first component consists of the EA objectives for an organisation which must be considered when embarking on an EA programme (Section 3.3). The next component addresses the potential benefits of EA programmes to an organisation and must be considered prior to adoption as part of a ROI analysis (Section 3.4). The third component investigates the risks and challenges of EA to an organisation (Section 3.5).

The EA components included in this model are based on the TOGAF Content Metamodel (The Open Group, 2009b, 2009c) and include Business Architecture, Application Architecture, Information Architecture and Technology Architecture. It is proposed for this study that the Business Architecture component is mapped at the strategic level of an organisation and consists of organisational strategy, stakeholder concerns and vision of an organisation. The constraints, risks and challenges as well as opportunities or potential benefits of an organisation should also be included in the organisational strategy. The Data Architecture and Application Architecture which are included at the Operational level should consist of the data management and systems integration components to achieve the benefits of audit compliance data integrity and the integration of EMIS systems with other systems in the organisation. The Technology Architecture is included in the Technological level and should consist of the technical infrastructure and the tools and technologies which should be aligned with the other three EA components on the strategic and operational levels in the diagram. The tools and technologies include the various EA models and modelling notations (Section 3.6) as well as the technology strategies used for EA (Section 3.7) and the systems used (Section 3.8).

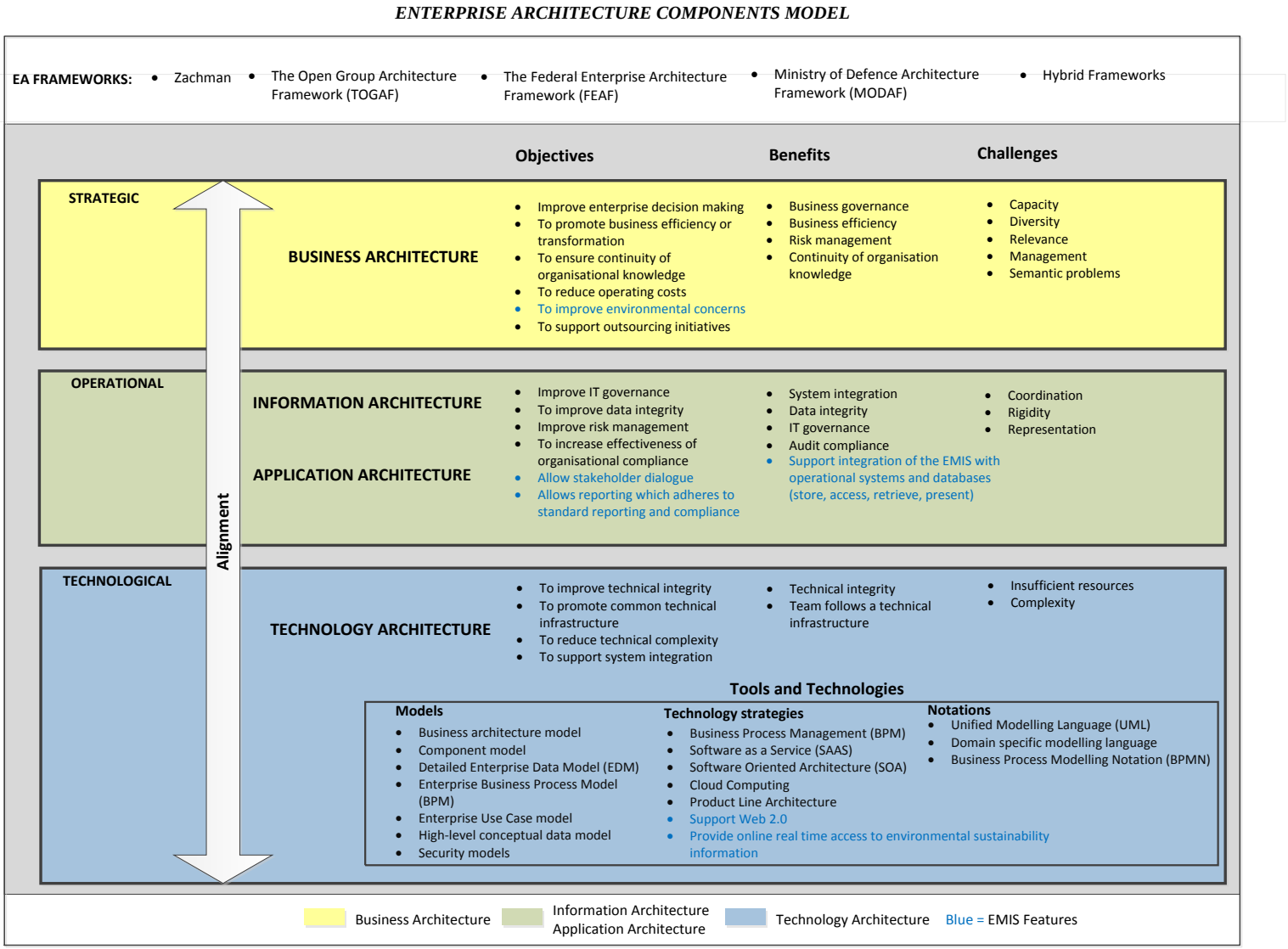


Figure 3-9: EA Components Model

3.10 EA for EIM Toolkit (Version 1)

The proposed EA for EIM Toolkit (Version 1) is based on the literature found in Chapter 2 and Chapter 3 (Figure 3-10). The elements in each of the chapters are aligned in this diagram and this study propose that all elements should be aligned in order to overcome silos in information and in IS. The alignment of these elements includes identifying the objectives, strategies, tools and technologies of each in conjunction with each other, to take into consideration the impact each will have on the other components and vice versa. The benefits, objectives, standards, tools and technologies also have to be aligned across the three process levels in an organisation. It is proposed that this alignment should be achieved by the use of EA for effective environmental sustainability reporting and management in an organisation.

The theoretical model represents the problem that had to be investigated in this study regarding environmental sustainability reporting. It is found in literature that the main objective of an EA is for business-IT alignment in organisations (Iyamu, 2011; Pereira, 2005; Ross *et al*., 2006; Schekkerman, 2005; Wang *et al.*, 2008). A theoretical model is proposed which can be used by organisations as an EA for EIM Toolkit (Version 1). This toolkit and can assist organisations with planning their environmental sustainability reporting and management by incorporating this as part of their planning which can be used for the support of EIM. The toolkit consists of the four EA components namely the Business Architecture, Information Architecture, application Architecture and Technology Architecture. The four architecture levels are mapped to the three process levels of the organisation, namely the strategic level, operational level and the technological level. The EA for EIM Toolkit (Version 1) will be expanded and updated during the survey study (Chapter 5) and case study (Chapter 6) of this research.

ENTERPRISE ARCHITECTURE TOOLKIT FOR ENVIRONMENTAL INFORMATION MANAGEMENT

EA FRAMEWORKS: • Zachman • The Open Group Architecture Framework (TOGAF) • The Federal Enterprise Architecture Framework (FEAF) • Ministry of Defence Architecture Framework (MODAF) • Hybrid Frameworks

COMPLIANCE AND STANDARDISATION: • The Global Reporting Initiative (GRI) • The International Organisation for Standardisation (ISO) • Environmental Management System (EMS)

		Objectives	Benefits	Challenges
STRATEGIC	**BUSINESS ARCHITECTURE**	• Improve enterprise decision making • To promote business efficiency or transformation • To ensure continuity of organisational knowledge • To reduce operating costs • To support outsourcing initiatives • To improve environmental concerns • To understand how the company influences and is influenced by expectations about sustainable development • To initiate programs to eliminate hazardous substances in materials and parts purchased	• Business governance • Business efficiency • Risk management • Continuity of organisation knowledge • Raises awareness of and focus on sustainable practices and issues • Strategic alignment • Demonstrating good corporate citizenship • Reputation enhancement • Greater transparency	• Capacity • Diversity • Relevance • Management • Semantic problems • Compliance and Standardisation • Short-term versus long-term • Buy-in to disclose data • Transparency and disclosure to stakeholder • Moving from costs to revenues
OPERATIONAL	**INFORMATION ARCHITECTURE** **APPLICATION ARCHITECTURE**	• Improve IT governance • To improve data integrity • Improve risk management • To increase effectiveness of organisational compliance • To improve technical integrity • Allow stakeholder dialogue • Allows reporting which adheres to standard reporting and compliance • To improve sustainability marketing; • To control production processes with regard to emissions/effluents control and waste minimisation • To increase sustainable use of natural resources • To allow stakeholders to use the reports to assess companies in terms of standards and other regulatory factors • To compare performance between companies	• System integration • Data integrity • IT governance • Audit compliance • Support integration of the EMIS with operational systems and databases • Compliance with legal and other requirements • Market access • Improved efficiency • Strengthens stakeholders relationship • Better brand alignment • Improved productivity • Help to set targets and KPIs	• Coordination • Rigidity • Representation • Communication between departments • Quality of data • Data collection and access to information • Quantifying the qualitative
TECHNOLOGICAL	**TECHNOLOGY ARCHITECTURE**	• To improve technical integrity • To promote a common technical infrastructure • To reduce technical complexity • To support system integration • To improve communication with stakeholders about sustainability using the sustainability report as a dialogue tool	• Technical integrity • Team follows a technical infrastructure • Competitiveness	• Insufficient resources • Complexity • Traditional accounting systems

Alignment

Tools and Technologies

Models	Technology strategies	Notations
• Business architecture model • Component model • Detailed Enterprise Data Model (EDM) • Enterprise Business Process Model (BPM) • Enterprise Use Case model • High-level conceptual data model • Security models	• Business Process Management (BPM) • Software as a Service (SAAS) • Software Oriented Architecture (SOA) • Cloud Computing • Product Line Architecture • Support Web 2.0 • Provide online real time access to environmental sustainability information • Spreadsheets • Sustainability reporting systems • Web-based reporting tools • Internal Information Systems	• Unified Modelling Language (UML) • Domain specific modelling language • Business Process Modelling Notation (BPMN)

Business Architecture | Information Architecture Application Architecture | Technology Architecture | Blue = Environmental Sustainability and EMIS Features

Figure 3-10: EA for EIM Toolkit (Version 1)

3.11 Conclusions

The four most prevalent EA frameworks are the Zachman framework, TOGAF, FEAF and MODAF (Section 3.2). Organisations are faced with the challenge of aligning their organisational strategies to the IT strategies for teams and employees to follow a common framework and for managers to make effective and efficient decisions. Therefore organisations mainly use EA to align their business-IT strategies and to support systems integration to overcome this challenge. The main benefit found for EA at a strategic level in an organisation is business governance. This enables organisations to produce consistent EA process outputs and easily manage EA objectives without having to change the structure of the organisation's operations.

EA models and technology strategies are used in organisations to reduce the complexities of both the organisational processes and the complexities of IT. It is found that the use of EA models not only reduces the complexities of the organisation and IT but also helps organisations to make informed decisions more quickly to respond to market changes. Different EA models (Section 3.6) and EA technology strategies (Section 3.7) can be used to support the effective and optimal development of an EA.

Several architectures for environmental sustainability reporting have been proposed (Section 3.8). An EMIS should accommodate specific capabilities and features. These features can be supported by the capabilities identified in an EA (Section 3.9). Therefore it is proposed that a successfully adopted EA can address the challenges of environmental sustainability. This makes an EA valuable to address supporting EIM as the enterprise structure of an organisation can be represented by an EA (Section 3.10). Therefore the environmental strategy of an organisation can seamlessly be integrated into the EA of an organisation. Therefore it is proposed that an EA can be used to align the organisational strategies, and the environmental sustainability strategies with the IT strategies.

The research questions addressed in this chapter were successfully answered since the objectives, benefits and challenges of EA adoption in organisations were identified through research question two (RQ2) and several frameworks, tools and technologies adopted for EA by these organisations were investigated and answered through research question three (RQ3).

A theoretical model (Figure 3-10) was created based on the literature study from Chapter 2 (Figure 2-7), EIM and reporting and the concepts addressed in Chapter 3 involving the EA elements and components (Figure 3-9). The following chapter will address the research design process of this study and discuss how the research design process of this study will be implemented.

Chapter 4 Research Design

4.1 Introduction

The previous chapters identified the status of environmental sustainability reporting and Environmental Information Management (EIM) as well as EA adoption in organisations. A research design helps to clarify the overall view of the reason for the chosen research methods and serves as a plan for how the research questions are answered (Saunders *et al.*, 2009). The main research question of this study is: "*How can Enterprise Architecture be used to support environmental sustainability strategies and environmental information management and reporting in organisations?*". This chapter explains the research design of this study and therefore characterises how the research questions (Chapter 1) are answered.

This chapter will focus on the research objective: *To identify and apply a suitable research methodology for this study* (RO4). Therefore the research process for this will outline the research philosophy, the research approach, the research strategy and the data collection and analysis methods (Section 4.2).

The survey strategy process explains how the survey study will be done for this research to empirically verify the theory identified in Chapter 2 and Chapter 3 by using online questionnaires to collect data (Section 4.3). The case study strategy involves many aspects identified in theory and will be defined to establish the process for the purpose of this research. An additional data collection method for the case study will be interviews (Section 4.4). The data will be analysed by using appropriate statistical and qualitative analysis methods to present the factual findings and results (Section 4.5).

Ethical clearance for this research was obtained (Section 4.6) and several key observations and conclusions are reported (Section 4.7). Figure 4-1 provides an overall picture of this chapter structure.

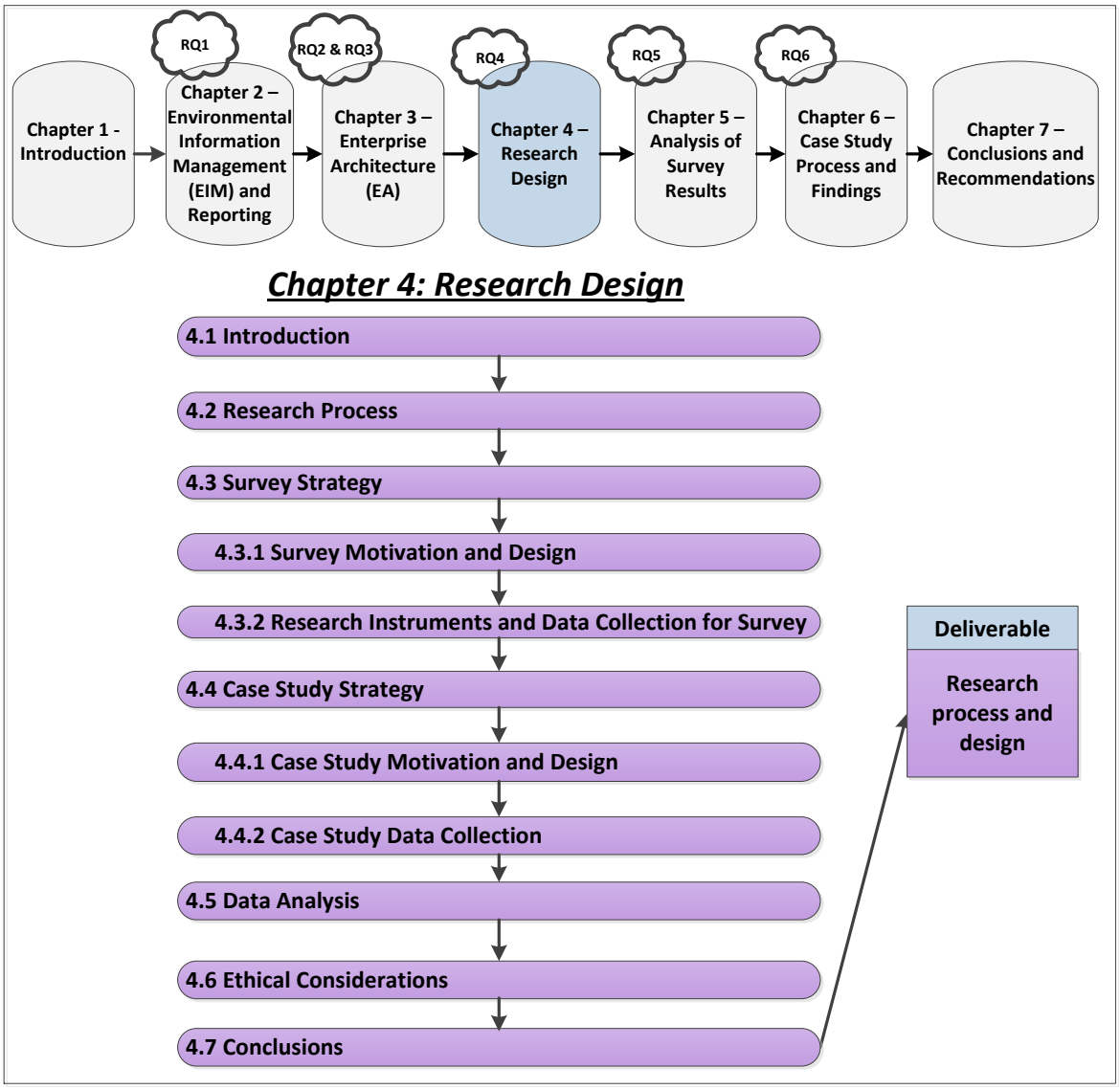


Figure 4-1: Chapter 4 Structure

4.2 Research Process

Saunders *et al.* (2009) proposes that the process which is chosen for a research study involves a number of steps identified in the research "onion" (Figure 4-2). The steps involved in this study will be to identify the research philosophy, approach, strategy, data collection and data analysis methods. This research involves the interpretivist and the positivist philosophies which involve the inductive and deductive research approaches.

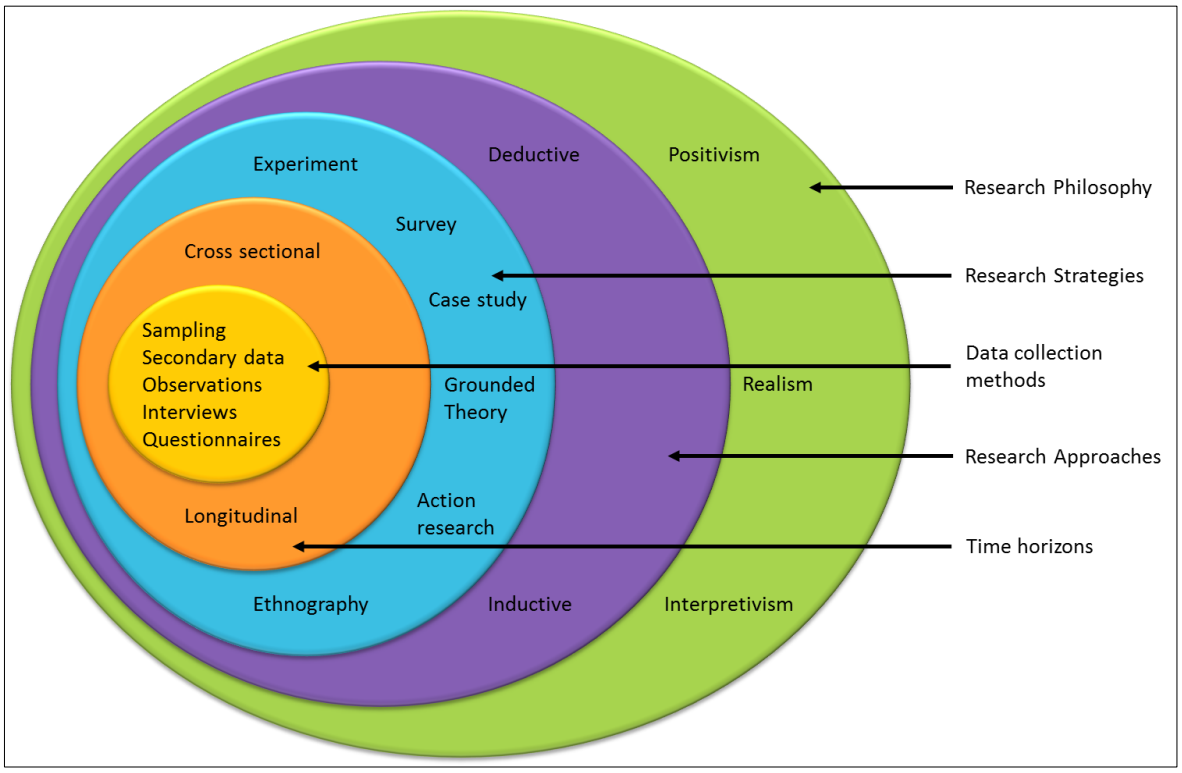


Figure 4-2: The Research Onion Process, adapted from Saunders et al. (2009)

This research will focus on addressing the problem statement (Section 1.3) by answering the research questions (Section 1.6). Three main research philosophies exist, namely: positivism, realism and interpretivism (Saunders *et al.*, 2009; Dunne *et al.*, 2005). These research philosophies are described as:

- *Positivism*: one aspect known to the positivist researcher is that research is done in a "value-free" manner, the researcher has no involvement in the data collection process for example, data are collected systematically in a computerised fashion (Saunders *et al.*, 2009). Another aspect of a positivist is to find the laws, patterns and regularities in the world, and one way of doing this is through experiments and by setting hypotheses (Oates, 2005). Therefore repeatability is key for the researcher as the experiment is relied upon and not the results, that is the experiment should produce the same results carried out by different researchers and if it does not the hypothesis is disproved.
- *Realism*: is based on "reality is the truth" and the reality or object is independent of the human mind (Saunders *et al.*, 2009). The two types of realism are 1) direct, that the human senses are accurate and 2) critical, that the human senses create sensation, for example some imagery effects on television.

- *Interpretivism*: the interpretivist belief that it is important to distinguish whether research is being conducted with people rather than with objects such as a computer (Saunders *et al.*, 2009). Therefore a critical aspect is that research has to view the research subjects in their world from their point of view, which can become a challenge. It is also known that this philosophy is well adapted for real world business research and scenarios.

This research will adopt both the interpretivist and positivist philosophies. Interpretivism, as stated in the research problem (Section 1.3) for this research is evident in real world business scenarios. Research also identifies many qualitative studies using this philosophy (Dunne *et al.*, 2005).

The deductive approach usually starts with a general theory and ends with more specific observations and theories, whereas the inductive approach starts with observations and tends to end with generalised theories (Hyde, 2000). An important characteristic of deduction is generalisation, where the results of a sample can be generalised to the context of the sample field, and a known advantage of induction is the opportunity to use smaller samples, for example in a case study (Saunders *et al.*, 2009). Often research is done using both the inductive and deductive theories as this is seen as an advantage (Saunders *et al.*, 2009). This study will use both these approaches. The inductive approach will be used to identify theories not previously identified in order to derive the proposed elements for the EA toolkit and the deductive approach will be used to address the main research question and to empirically validate the elements of the proposed EA toolkit.

The research strategies for this research are the case study and survey strategies which will involve some qualitative data collection. An industry survey will be conducted which will consist of two questionnaires which will be online therefore the data will be collected in an automated manner.

Quantitative research focuses on measuring quantity while qualitative research focuses on quality of the phenomenon (Rajasekar *et al.*, 2006). Hence, qualitative research is descriptive of nature and the use of words for reasoning is important, whereas quantitative research focus on describing data through quantities. Qualitative data is usually accessed by using surveys, interviews and observations (Saunders *et al.*, 2009). It is important to note that qualitative and quantitative methods are not mutually exclusive (Rajasekar *et al.*, 2006).

Mixed methods are often used in research to increase reliability and the reliability of the data (Saunders *et al.*, 2009). This study will make use of both qualitative and quantitative research methods as well as using two types of research strategies namely survey and case study research and will include two types of data collection methods namely online questionnaires and interviews.

Being able to use two types of research strategies will allow for triangulation of the use of data in this study (Saunders *et al.*, 2009). This triangulation will also allow for verification of the data in this study, where the data collected using the online questionnaire can be verified during the interviews. Therefore this study will also confirm the reliability and validity of the survey and case study results (Saunders *et al.*, 2009). Reliability will be confirmed by using Cronbach's alpha statistical test and validity will be confirmed by using pilot studies and pilot versions of the questionnaires and interview questions that can be verified by experts.

Two types of sampling exist, namely, probability and non-probability sampling which consist of different sampling techniques (Saunders *et al.*, 2009). The probability sampling consists of techniques such as simple random, systematic, stratified random and cluster techniques. The non-probability sampling consists of techniques such as quota, purposive, snowball, self-selection and convenience techniques. The sampling technique which will be used in this study is the purposive technique which allows for certain cases of the sample to be selected to best answer the research questions (Saunders *et al.*, 2009). In this study these cases will be based on the size of the organisation, IT infrastructure and the job title of the participant.

Figure 4-3 illustrates all the elements that will be followed in the research process for this study. Firstly a literature review was conducted and then the survey strategy will follow. The top five organisations will be chosen based on their ranking from the questionnaire results to take part in the case study. The results from the survey study and the proposed set of guidelines for the EA for EIM Toolkit will be verified and updated based on the case study findings.

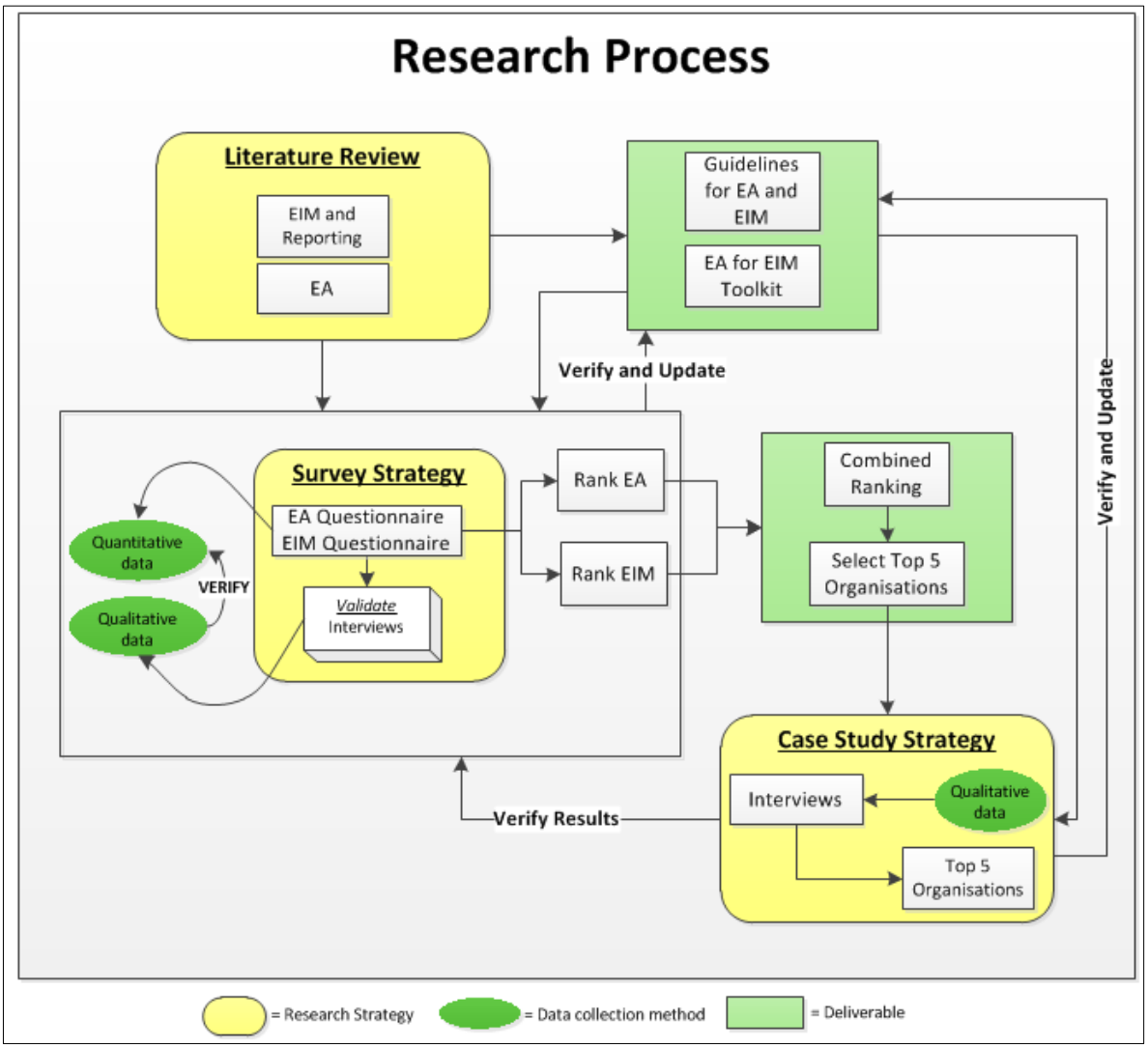


Figure 4-3: Research Process

4.3 Survey Strategy

A survey strategy is often used to answer the "who, what, where, how much and how many" questions and is also associated with the deductive approach (Saunders *et al.*, 2009). Large quantitative data collection and analysis from selected samples are made possible using the survey strategy.

Survey research can be used "*to answer questions that have been raised, to solve problems that have been posed or observed, to assess needs and set goals, to determine whether or not specific objectives have been met, to establish baselines against which future comparisons can be made, to analyse trends across time, and generally, to describe what exists, in what amount, and in what context*" (Isaac and Michael, 1997, p. 136). This research will use a survey strategy to answer the research questions one to three (RQ1 – RQ3) and to establish how the research objectives one to three (RO1 – RO3) could be met.

4.3.1 Survey Motivation and Design

Two types of design exist for survey research. The first design is longitudinal where data are collected over a period of time using the same sample of respondents. The second is cross-sectional which is a survey design whereby data are collected at one point in time. This will be used as the survey design for this research as it is a convenient and cost saving way of collecting data from different sized sample of respondents (Saunders *et al.*, 2009).

A survey study provides an opportunity to collect data that are not available from other sources, data which can be standardised as the same information is collected from different respondents (Owens, 2002). Data collected from a survey study can also be used to justify and confirm information from secondary sources through analysis.

A pilot study will also be referred to as "pilot survey study" will be used to confirm the processing of the questionnaires for this research (Saunders *et al.*, 2009). The pilot study will provide an evaluation of the structure of the questions, the length of the questionnaires and the consistency of the questions to confirm the validity of the questions. Feedback based on the pilot study will be used to formulate the final questionnaires for the survey study.

One of the research strategies of this study is the survey strategy (Figure 4-4). The participants will be requested via an email, containing a cover letter (Appendix F) to participate in the online questionnaire. The participants will then have to respond to the email which will confirm whether they agree to participate or not. The email will allow for the participants to contact the researcher with any questions regarding the survey study; reasons for not being able to participate and to forward the request to other appropriate participants either within their organisations or in other relevant organisations. The links to the online questionnaires will then be sent to the participants for completion. Any missing or incomplete data will be confirmed with via telephone interviews and wherever possible face-to-face as this will be most convenient and cost effective. The data obtained from the participants will be automatically downloaded in an Excel spreadsheet for quantitative analysis purposes. The qualitative data will be then analysed by using different descriptive statistics and a qualitative tool Atlas.Ti in order to present the data using tables and graphs.

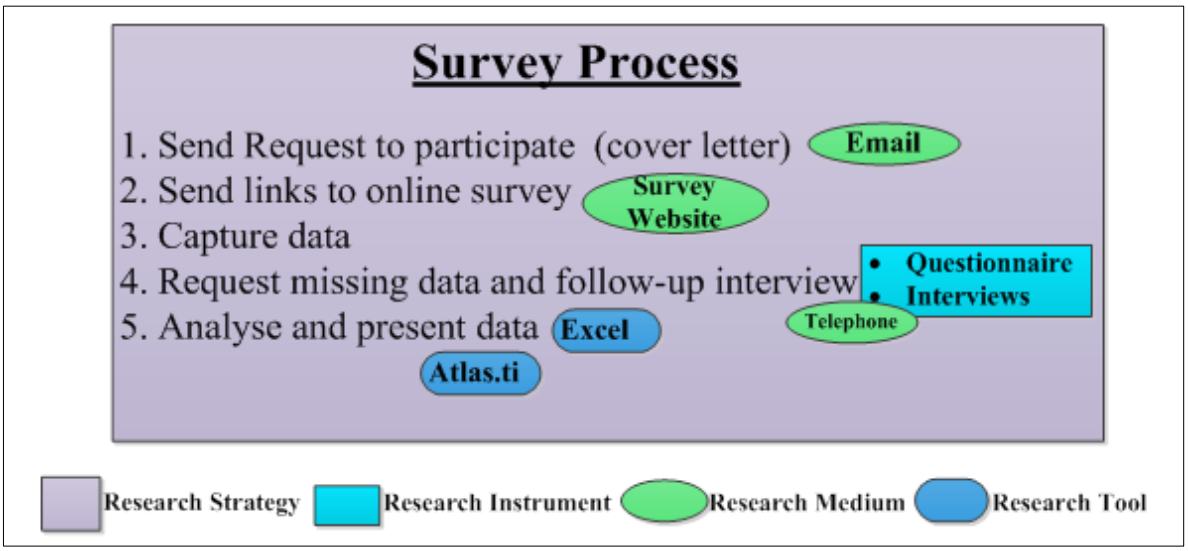


Figure 4-4: Survey Strategy Process

4.3.2 Research Instruments and Data Collection for Survey

The research instruments for the survey study of this research will consist of two online questionnaires, namely the EA questionnaire (Appendix I) and the EIM questionnaire (Appendix J). Table 4-1 illustrates the research instruments for this study. The EA questionnaire of this study will be structured into 11 sections and the EIM questionnaire into nine sections. The questionnaires sections will cover the topics and aspects of this research. Different measures such as Likert scales rating questions, list questions, category questions and open-ended questions will be used to design the questionnaire sections (Saunders *et al.*, 2009).

The questions will be based on a 5-point Likert scale which will allow the participants to rate and select the appropriate options for the various items in the questionnaires (Sekaran and Bougie, 2009). The list questions will consist of lists of options where the respondents will be able to choose one or more options, the category questions will include categories such as age categories and open-ended questions will be used to obtain qualitative responses from the participants.

Table 4-1: Research Instruments

Research Instrument	Questionnaire Sections	Description	Measures	Data Analysis and Presentation
EA Questionnaire	EA_{1-2}	Organisation and biographical details	List and category questions	Graphs (bar charts and pie charts)
	$EA_{3,8}$	EA frameworks	List questions and rating scale	Graphs (bar charts and pie charts) Descriptive statistics (Mean, standard deviation), Cronbach's alpha, Cohen's *d*, *t* test
	EA_4	EA objectives	Rating scale	Mean, Cronbach's alpha Cohen's *d*, *t* test and standard deviation
	EA_{5-6}	Models and modelling notations	Rating scale	Cronbach's alpha, Cohen's *d*, *t* test, Descriptive statistics (Mean, standard deviation)
	EA_7	Technology strategies	Rating scale	Mean, Cronbach's alpha, Cohen's *d*, *t* test and standard deviation
	EA_{9-11}	EA benefits and challenges	Rating scale and qualitative questions	Mean, Cronbach's alpha, Cohen's *d*, *t* test, standard deviation and Atlas.Ti
EIM Questionnaire	EIM_{1-2}	Organisation and biographical details	List and category questions	Graphs (bar charts and pie charts)
	$EIM_{3,6}$	Sustainability reporting	List questions and rating scale	Graphs (bar charts and pie charts) Mean, Cronbach's alpha, Cohen's *d*, *t* test and standard deviation
	EIM_4	Environmental sustainability benefits and challenges	Rating scale and qualitative questions	Mean, Cronbach's alpha, Cohen's *d*, *t* test, standard deviation and Atlas.Ti
	EIM_5	Environmental sustainability standards	Rating scale	Mean, Cronbach's alpha, Cohen's *d*, *t* test and standard deviation
	EIM_7	Environmental sustainability tools	Rating scale	Mean, Cronbach's alpha, Cohen's *d*, *t* test and standard deviation
	EIM_8	Environmental sustainability objectives	Rating scale	Mean, Cronbach's alpha, Cohen's *d*, *t* test and standard deviation
	EIM_9	Environmental information	Rating scale	Mean, Cronbach's alpha and standard deviation

4.4 Case Study Strategy

The case study strategy is defined by Yin (2009, p. 4) as a research method that is "*used in many situations, to contribute to our knowledge of individual, group, organisational, social, political, and related phenomena*". Case study research allows the researcher to holistically attain meaningful characteristics of real-life events, such as organisational and managerial processes (Yin, 2009). It is also found that case study methods provide much more detailed information compared to other methods such as the survey method (Neale *et al.*, 2006).

Case studies can however be used with other methods, such as surveys in order to obtain detailed information. The "how" and the "why" research questions are usually associated with case study research (Yin, 2003). There are three types of case studies namely: exploratory, descriptive and explanatory case studies, which are categorised by Yin (2003). Yin (2009) also differentiates the primary design for case studies are between single and multiple case studies.

Exploratory, descriptive and explanatory research can be used by any research strategy (Yin, 2003). Exploratory case studies are used where a case has to be explored as the evaluation of the case has no clear or single set of outcomes. Descriptive case studies are used to describe the case and the real-life context in which it is happening. Explanatory case studies would be used to answer complex questions which cannot be addressed in a survey or other strategies and therefore would be answered through some form of evaluation.

A single case study is used to represent a unique case and a multiple case study is used to address differences within or between cases (Yin, 2003). This research will use a multiple case study with several cases (organisations) in different organisations and will make use of the explanatory method to address the questions during the interviews that could not be included in the survey study.

4.4.1 Case Study Motivation and Design

This research will conduct an in-depth investigation of a small number of cases in order to address a broad range of concerns related to EA and EIM. Multiple cases in a case study increases the credibility of analysis and results (Yin, 2003). Explanatory case studies can help the researcher to find answers to the "why" and "how" research questions (Saunders *et al.*, 2009; Rajasekar *et al.*, 2006), for example to explain why a certain case is what it is and how it can be adapted to answer the questions. In this research, the main research questions were to investigate "how" an EA can be used to support EIM and reporting.

Explanatory research involves collecting and analysing quantitative data and then collecting and analysing qualitative data which is a follow-up for the initial quantitative data (Creswell and Clark, 2011). This process is to use the qualitative data for explaining the quantitative results to establish further findings or new questions. This process also supports the researcher to use the quantitative results, or new findings in order to purposefully select participants for example, for a case study which involves further qualitative data collection and analysis. The quantitative results can also be used to formulate questions for the qualitative case study. This research will focus on a survey study of two questionnaires which will mainly consist of quantitative questions with a few qualitative open-ended questions. The results from the survey study (Chapter 5) will be used to confirm the proposed toolkit which is represented by the theoretical model (Figure 3-10). This will be used to formulate questions for the qualitative case study (Chapter 6).

Yin (2009) identifies a rationale for a case study, representing a critical case for testing a well-formulated theory. This theory should represent a clear set of propositions and circumstances, where the propositions are believed to be true, this case can then be used to establish whether the set of propositions is correct or whether an alternative set could be more relevant (Yin, 2009). This research will use a case study strategy to establish whether the proposed theoretical model, the EA toolkit for EIM (Section 3.10) can be validated by the selected participants for the case study.

There are four aspects of case studies (Lazar *et al.*, 2010), namely:

- *In-depth investigation of a small number of cases:* Case studies make use of in-depth and broad investigations of a smaller number of cases to be able to address a number of concerns. This case study will include a number of selected participants who will represent their organisations in their input where interviews will be based on the individual situation of each participating organisation as well as on the validation of the proposed EA;
- *Examination in context:* Case studies occur in a normal setting, this case study will occur in some form of office space at the participant's organisation;
- *Multiple data sources:* The data collected for case studies are often from multiple data sources and collection techniques in order to increase the reliability and validity of the data. The results of the case study will include input from participants in different disciplines and from different organisations that will be involved in the survey study. The other source of data collection will be from the interviews with the selected participants; and

- *Emphasis on qualitative data analysis:* The data that will be collected for the case study of this research will be qualitative.

The case study strategy is well-suited for this research. The risks and constraints of a case study are identified and will be resolved for this case study as follows (Lazar *et al.*, 2010; Flyvbjerg, 2006; Hofstee, 2006):

- *The risk of losing focus:* The multiple cases of the case study will be focused and investigate and based on a selection criterion involving between five and eight organisations. These organisations will be selected from the participants taking part in the industry survey study and will be those participants who would have ranked very positive, positive and neutral in both questionnaires combined. If any difficulty occurs where any of the chosen participants cannot take part in the case study, then those organisations which are willing to participate will be selected for the interviews during the case study;
- *Generalisability of results:* A target of a minimum 30 South African organisations from a broad range of industries will be needed to take part in the survey study. Respondents from these organisations, in most cases two different respondents from both the EA and sustainability reporting disciplines need to complete the two questionnaires, one for the EA topic and one for the sustainability and EIM and reporting topic. Therefore the results from the case study will be used to confirm the results from the survey study and these results cannot be generalised to those organisations which took part in the survey study from the respective disciplines;
- *Subjectivity:* A pilot survey study will be completed. Therefore, any form of subjectivity identified in the pilot survey study will be removed and the final survey study will be completed; and
- *Time consuming*: This constraint will consequently allow only selected participants from each of the two fields of expertise from each organisation to take part in the case study.

The findings of case study can be useful for generating and testing hypotheses (Hofstee, 2006). However a case study is an inductive approach and for this approach theories can be developed from the data collected based on the data analysis and, therefore require no hypotheses (Saunders *et al.*, 2009). In this study no hypotheses will be formulated but instead the design process will be guided by proposed theories from literature to design the survey study questions. The results from both the proposed theories in literature and the survey study will be used to design the case study questions.

4.4.2 Case Study Data Collection

The results from the survey study will be used to select the top five organisations which will take part in the case study for this research which will include interviews with each of these organisations. The case study interviews will consist of structured, semi-structured and unstructured interview questions (Gill *et al.*, 2008). The structured interviews will provide an opportunity to ask confirmatory questions based on the industry survey questionnaires. The semi-structured interviews will allow the participants to give informative statements which can later form part of the pre-determined qualitative categories and themes. The unstructured interviews will be used to gain rich information during the case study regarding the topics at hand to address in more detail the research questions and objectives that could not be covered in the online questionnaire.

Each type of interview will be used during the case study to validate the questionnaire responses and the EA toolkit for EIM as well as to eliminate any ambiguity. The interviews that will be conducted during the case study will be used to find suggestions on how to improve the EA toolkit for EIM as well as to identify future research topics for those suggestions that might be out of the scope of this particular study.

The case study strategy process (Figure 4-5) will be started after the survey results have been analysed with the help of a statistician. The statistician will be required to create a scoring system which will then be used to rank the participants on an overall score for both the EA and the EIM responses. A number of respondents from the sample will be selected based on how well they have scored; the aim is to select those who have best-practice in place for both EA and EIM. The input from these respondents will assist in validating the proposed guidelines for the EA toolkit for EIM. Any additional guidelines will be illustrated in the final EA toolkit for EIM.

All participants will be requested via an email containing a cover letter (Appendix G) to participate in the case study. The covering letter will include information about the organisations and that the information given by the participants will be dealt with confidentially. Therefore mock names and reference numbers will be used to describe the participants and organisations. The email will also contain a brief explanation of what the case study will involve and the purpose thereof.

On response from those participants who agreed to participate, a date will be scheduled for the telephone interviews to take place and another email will be sent containing the proposed guidelines and best-practice for the EA toolkit for EIM. The respondents will be required to read through the guidelines and study the EA toolkit for EIM, this will assist to conduct the interviews within a maximum of 30-minutes. The recorded interviews will be transcribed by using a computer software program (Listen N Write) which allows for a controlled speed on the play-back function.

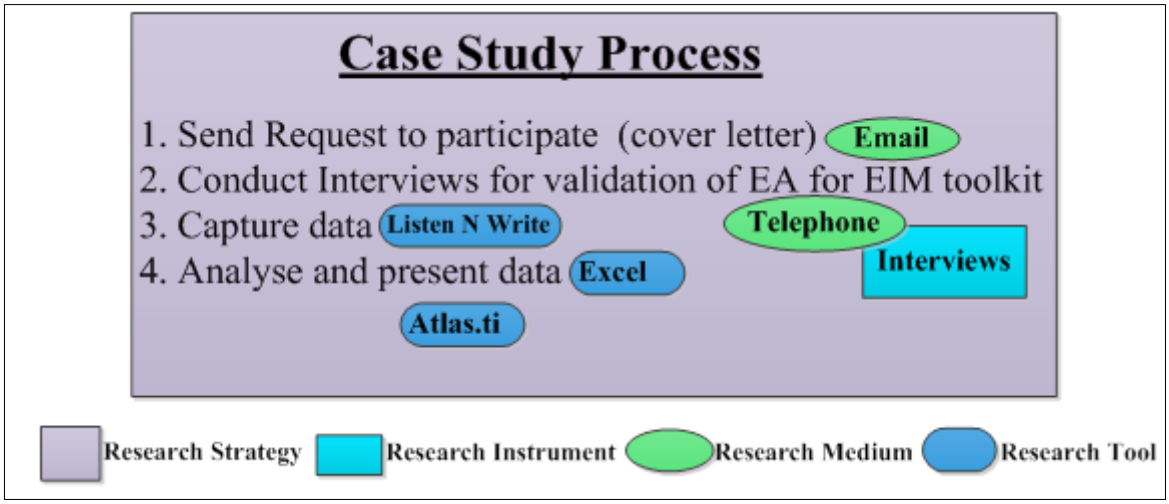


Figure 4-5: Case Study Strategy Process

4.5 Data Analysis

The four data analysis components that will be used in this study are: data collection, data display, data reduction and drawing conclusions (Miles and Huberman, 1994). The focus of this research will be enhanced by using data reduction. The primary data that will be collected in this study will go through a data reduction process where the results will be statistically and qualitatively analysed to simplify and explain the findings. Graphs will then be used to display the data. Conclusions will be drawn to represent the main findings as well as new findings. These data analysis components are connected; therefore these components can be done concurrently.

The qualitative data analysis techniques that will be adopted in this research are constant comparative analysis and content analysis (Anfara *et al.*, 2002). The constant comparative analysis will allow for categorising the collected data and then for developing new categories. These categories will then be attached to meaningful chunks of data. Content analysis involves data inspection in order to identify appropriate categories.

The quantitative data will be analysed using descriptive statistics (Saunders *et al.*, 2009). This type of analysis enables the researcher to describe and compare the quantitative data. Summary statistics such as: mean, median, frequency counts, variances, and standard deviations will be used to describe the numerical data for each variable. Statistical methods such as Cronbach's alpha tests will be performed to check for internal consistency of the data and to identify whether the data are reliable. The Cohen's *d* method will be used to check that the sample size is large enough to perform certain statistical tests (Cohen, 1988). The content validity method will be used by means of a pilot study where the respondents from the pilot study will confirm the structure, flow and context of the questions for the questionnaires (Saunders *et al.*, 2009). This will allow for checking the validity of the questions to be included in the final questionnaires of the survey study.

The collected data will be analysed in an expressive and a relative manner (Namey *et al.*, 2008). The ideas and concepts will be described and compared to those found in literature. Atlas.Ti is a qualitative data analysis tool which will aid in the development of categories and themes by coding the data.

4.6 Ethical Considerations

The research, for all purposes, abided by and followed on the proposals from the Research Ethics Committee (Human) of the Nelson Mandela Metropolitan University (NMMU) and ethical approval for this study was awarded by the NMMU Ethics Committee. The Ethics Clearance Reference Number is H12-Sci-CS-018 (Appendix A). In line with this, the researcher made it clear to the selected respondents from various organisations that their interests would remain anonymous.

4.7 Conclusions

The research design included a positivism philosophy which involved both the deductive and inductive research approaches. The research methods chosen are quantitative and qualitative whereby a survey and case study strategies will be used to conduct the research in this study. The main research instruments that will be used are online questionnaires and interviews. The data collection and analysis methods selected for this study are statistical measures such as Cronbach's alphas, content validity and mean values to measure the reliability and validity of the data and chosen qualitative measures will be used such as coding and categorising the responses by using Atlas.Ti.

The research question for this chapter was research question four (RQ4): *What is a suitable research methodology for this study?* This research question was answered by achieving the research objective four of this chapter (RO4), as a suitable research methodology was chosen for this study. The main deliverable of this chapter was the design of the research process for this study (Figure 4-3). The next chapter will report the survey study results and analysis of the results. Chapter 5 will also illustrate the updated EA toolkit for EIM which should reflect the proposed components for the EA toolkit for EIM which will be used during the case study (Chapter 6).

Chapter 5 Analysis of Survey Results

5.1 Introduction

The previous chapter highlighted the research process and the research strategies used in this study. This chapter will report on the results from the survey strategy which was designed to empirically evaluate the enterprise architecture (EA) for environmental information management (EIM) Toolkit (Version 1) which was introduced in Chapter 3 (Figure 3-10). This chapter reports on the results of a survey study undertaken with South African organisations to identify the elements in the EA for EIM Toolkit (Version 1). This will assist in answering the fourth research question (RQ5) namely, *What are South African organisations doing with regard to Enterprise Architecture and environmental sustainability reporting?*

The survey questionnaires were designed based on the theory identified in the theoretical model (Figure 3-10) called EA for EIM Toolkit (Version 1). The survey consisted of two questionnaires, the EA questionnaire regarding the EA activities in organisations, and the EIM questionnaire regarding environmental sustainability activities of organisations. The EA questionnaire was designed primarily on the study done by Ambler (2010), Other studies for the different sections in the questionnaire were identified in literature (Chapter 3). The EIM questionnaire was designed based on studies which were identified in literature (Chapter 2). The responses to the questionnaires were analysed to illustrate the findings. The organisations which participated consisted of medium to large organisations in South Africa.

A purposive sample was used to answer the final questionnaires. The participants and their organisations had to fit a certain profile (Section 5.2). A pilot study was undertaken and the reliability and validity of the questionnaires of the survey study was confirmed (Section 5.3). Quantitative and qualitative analysis of the EA results was completed (Section 5.4). Findings and results for environmental sustainability reporting and EIM were identified through quantitative and qualitative data analysis methods (Section 5.5). A face-to-face interview with an EA expert was conducted to verify some responses from their completed industry survey questionnaires (Section 5.6). Conclusions were derived based on the responses from the industry survey for organisations regarding their status about EA and environmental sustainability reporting and practices (Section 5.7). Figure 5-1 illustrates the structure for this chapter.

Three conference proceeding papers were accepted and published based on the results of this chapter. Two papers included the components of EA and addressed the challenges and information requirements of environmental sustainability reporting and the benefits of business-Information Technology (IT) alignment (Appendix C and Appendix D). The third paper included the analysis of the adoption and usage of EA (Appendix E).

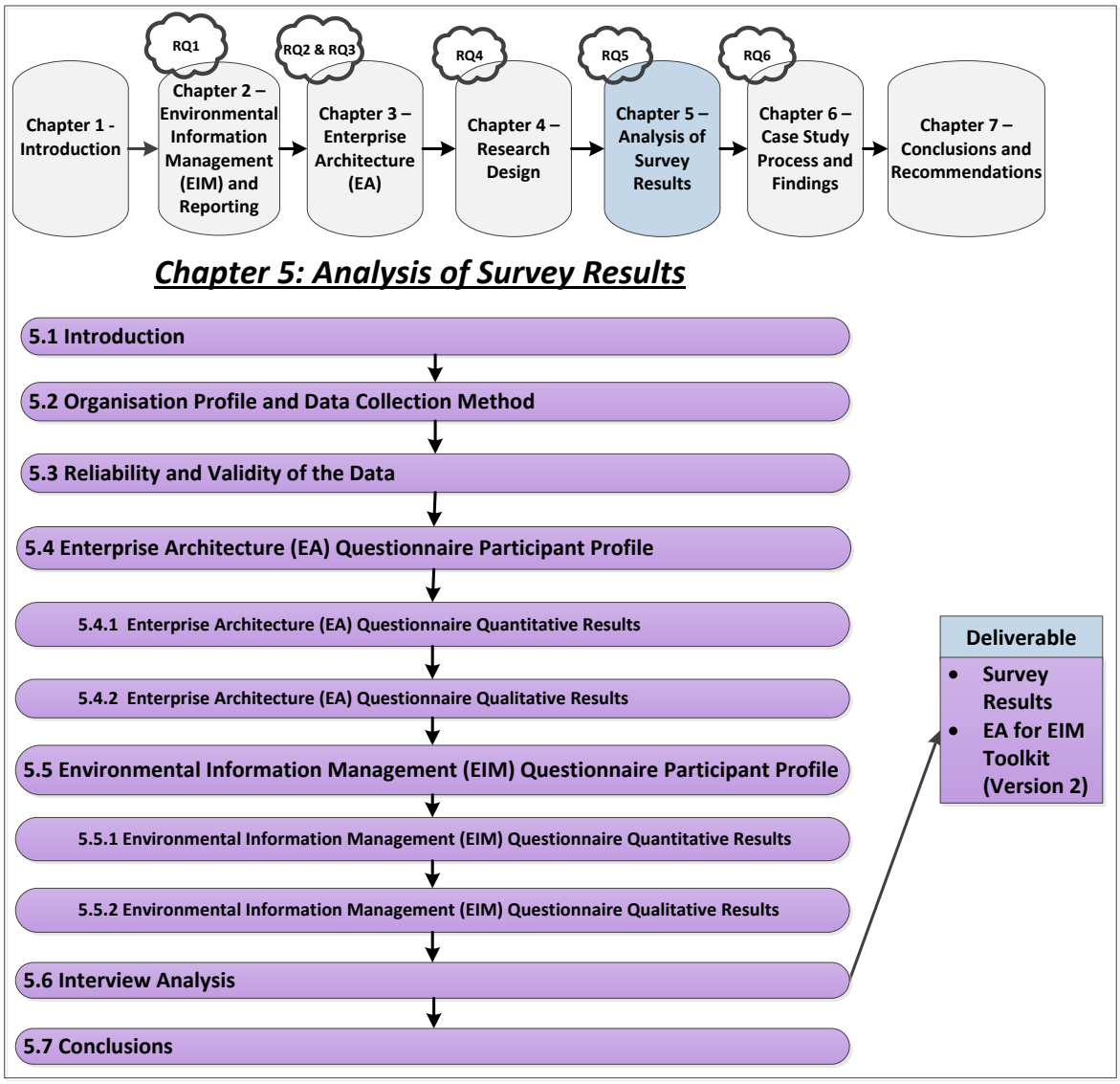


Figure 5-1: Chapter 5 Structure

5.2 Organisation Profile and Data Collection Method

A total of 182 participants were contacted by email to complete the online questionnaires (Appendix H, I and J) of which only 31 fully completed responses were received, indicating a response rate of 17%. The main reasons for the low response rate were that participants did not respond at all and some of the respondents could not be personally contacted.

Other reasons were participants refused to participate due to information security reasons in certain organisations and questionnaire responses were incomplete as certain sections of the questionnaire did not apply to specific organisations. The sample size (n = 31) allowed for statistical analysis as the rule of thumb is described in research to have a sample of 30 and larger to achieve as close to normal distribution as possible (Saunders *et al.*, 2009). The participating organisations were from a broad range of industries from all over South Africa and were classified into three main types of industries namely, Financial, Manufacturing and Service industries (Table 5-1). Six organisations were from the banking and financial industry, nine from the manufacturing industry and 16 from the service industry.

Table 5-1: Industries of Participating Organisations

Industry Category	Type of Industry	Companies (n)
Financial	Banking/Financial	6
	Total	**6**
Manufacturing	Agriculture	1
	Automotive	2
	Consumer Goods	1
	Manufacturing	2
	Paper/Packaging	1
	Pharmaceuticals	1
	Metals & Natural Resources	1
	Total	**9**
Service	Accounting and Audit	1
	Insurance	1
	Telecommunications/IT	4
	Insurance	3
	Aviation	1
	Logistics/Transportation	2
	Broadcasting	1
	Diversified Industrial	1
	Energy & Utilities	1
	Chemicals	1
	Total	**16**
	Total	**31**

The majority (81%) of organisations had over 500 employees, whilst 16% (n = 5) were medium-sized organisations with between 100 and 500 employees (Figure 5-2). Only one organisation had fewer than 100 employees. Fifteen organisations indicated that they have between 1 to 5 enterprise architects in their organisation and twelve reported that they have between 1 to 5 environmental sustainability staff (Figure 5-3). Two of the 31 organisations reported that they have more than 51 enterprise architects and six organisations reported that more than 51 employees are involved with environmental sustainability tasks in their organisations.

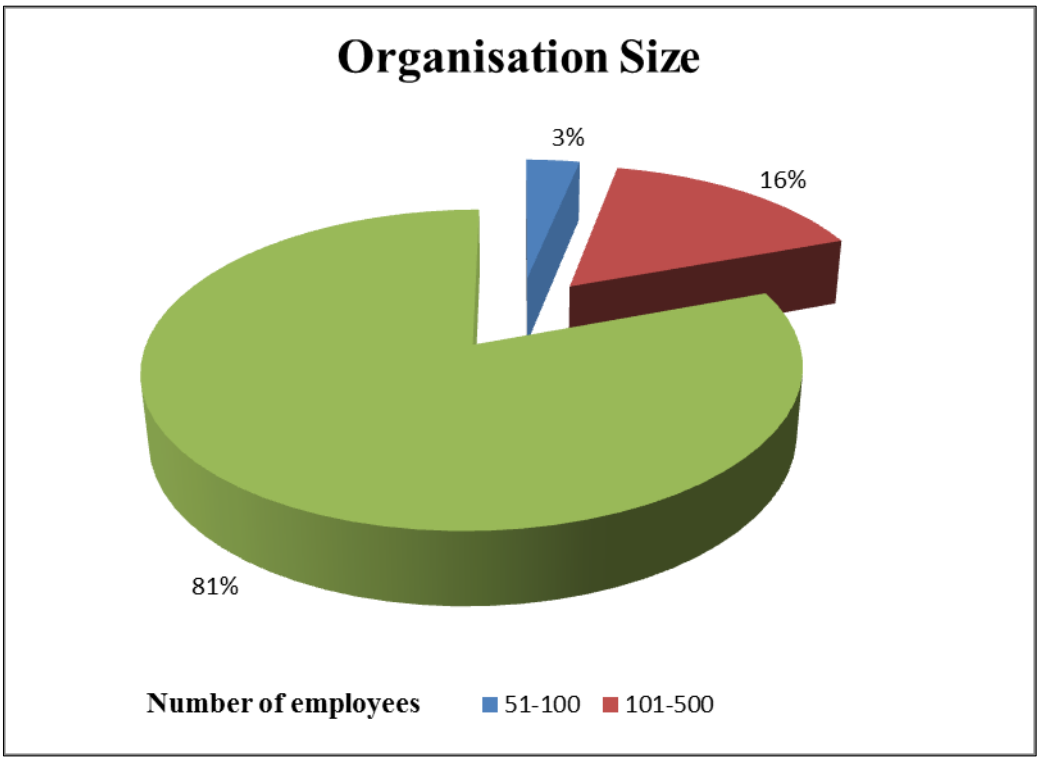
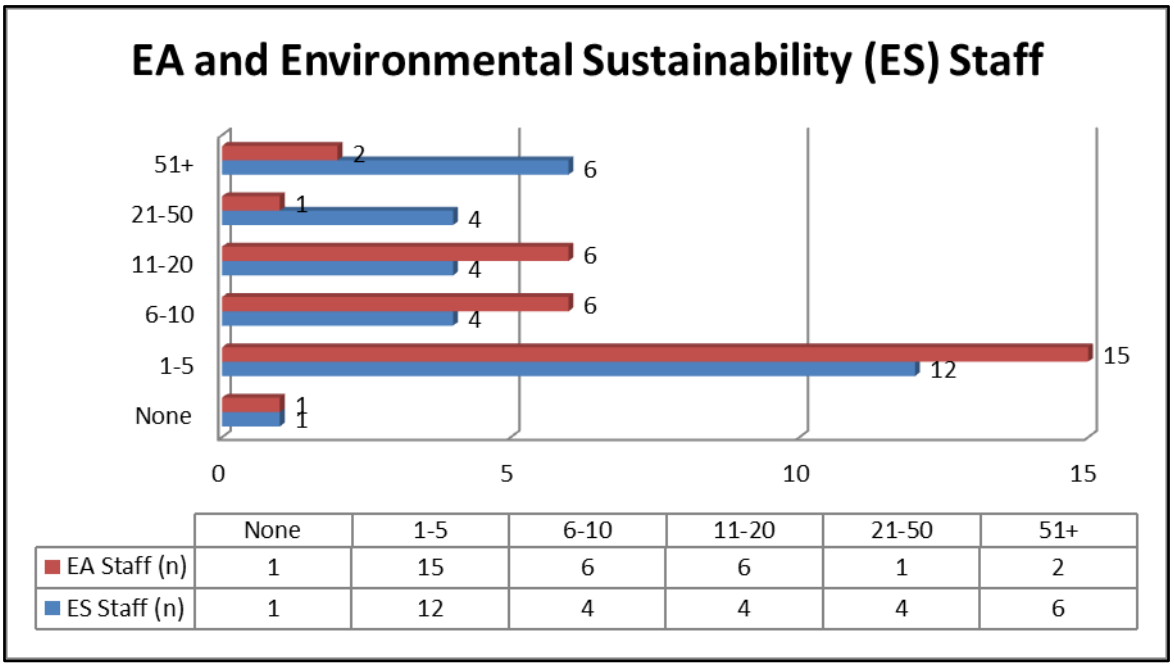


Figure 5-2: Size of Participating Organisations in terms of Number of Employees



	None	1-5	6-10	11-20	21-50	51+
EA Staff (n)	1	15	6	6	1	2
ES Staff (n)	1	12	4	4	4	6

Figure 5-3: EA and Environmental Sustainability Staff at the Organisations

5.3 Reliability and Validity of the Data

A pilot study was done to confirm the reliability and validity of both questionnaires whereby the respondent had to confirm the flow, structure and context of the questions (Saunders *et al.*, 2009). The reliability of both questionnaires was measured using Cronbach's alpha test for internal consistency. Cronbach's alpha coefficients greater than 0.70, the recommended minimum value for reliability (Nunally, 1978), were observed for most indices of the EA questionnaire sections (Table 5-2), with the exception of the section "EA Modelling Notations" with a value in the range 0.52 to 0.69. Nunally (1978) argues that in the early stages of basic research, coefficients between .50 and .69 are sufficient evidence of adequate reliability. The observed Cronbach's alpha coefficients were all in this interval or greater, thus confirming the reliability of the EA questionnaire sections.

Table 5-2: Cronbach's Alpha for EA Questionnaire Sections

EA Questionnaire Sections	Cronbach's Alpha
EA Objectives	0.95
EA Models	0.92
EA Modelling Notations	0.55
EA Technologies	0.87
EA Frameworks	0.89
EA Benefits	0.94

Cronbach's alpha coefficients for the EIM questionnaire were greater than 0.70, which were also observed for most indices of the EIM questionnaire sections (Table 5-3). There was an exception for the section "Stakeholder Concerns" which had an initial value of 0.45 but after removing the item "Environmental Issues" from this section, an acceptable value was observed of 0.77. Another exception occurred for the section "Tools and Technologies for Sustainability Reporting" which had an initial value of 0.51. This coefficient was between .50 and .69 and is sufficient evidence of adequate reliability (Nunally, 1978). The observed Cronbach's alpha coefficients were then found all in this interval or better, thus confirming the reliability of the EIM questionnaire sections.

Table 5-3: Cronbach's Alpha for EIM Questionnaire Sections

EIM Questionnaire Sections	Cronbach's Alpha
Organisational Reporting Processes	0.77
Standards for Sustainability Reporting	0.81
Stakeholder Concerns in Terms of Importance to Organisations	0.77
Tools and Technologies for Sustainability Reporting	0.51
Environmental Sustainability Objectives	0.92
Environmental Indicators	0.94

A *t* test was completed to find out if any differences existed between the questionnaires sections. The results of the interpretations were statistically significant and Cohen's *d* was completed to test for practical significance between the mean ratings of the different EA and EIM questionnaire sections to determine whether the sample used was significant to perform statistical tests (Cohen, 1988). Table 5-4 illustrates the intervals of statistical and practical significance which will be used to explain the significance of the findings for the questionnaire sections in this research study (Gravetter and Wallnau, 2009). The p-value represents a statistical and practical significance and all p-values that are less than 0.0005 will be reported as zero (Gravetter and Wallnau, 2009). Standard deviation (SD) was used to show the difference between the mean values of the different EA and EIM questionnaire sections. The SD values will be illustrated in different tables wherever appropriate from this point onward.

Table 5-4: Practical and Statistical Significance Interpretation Intervals

Inferential test		**Practical and statistical significance interpretation intervals**		
		Small	**Moderate**	**Large**
***t* test**	**Cohen's *d***	$0.2 < d < 0.5$	$0.5 < d < 0.8$	$d > 0.8$

* p-value ≤ 0.05; ** p-value ≤ 0.01

5.4 Enterprise Architecture Questionnaire Participant Profile

The majority (84%) of the participants who completed the EA questionnaire were males (n = 26) and only16% (n = 5) were female (Table 5-5). This supports studies (Foust-Cummings *et al.*, 2008; ITWeb, 2013; Philpott, 2012; Zweben, 2011) showing a higher percentage of males are employed in IT and are between the ages 34 and 50. Therefore the sample is fairly representative. Twelve (39%) of the 31 participants were in the age interval 41-47, nine (29%) were in the age interval 34-40 and six (19%) were older than 48 years.

Table 5-5: Biographical Information

Gender	**n**	**%**
Male	26	84%
Female	5	16%
Total	**31**	**100%**
Age	**n**	**%**
26-33	4	13%
34-40	9	29%
41-47	12	39%
48+	6	19%
Total	**31**	**100%**

The participants who completed the EA questionnaire (Appendix I) had a variety of job descriptions (Figure 5-4). One of the criteria for selecting the sample for this study was that they had to be in an IT-related profession, such as Business Process Manager, Enterprise Architect, Information Architect, IT Manager/Director, and Chief Information Officer (CIO) or other IT-related profession. Ten participants (32%) stated job titles of Information Communication Technology (ICT) Audit Director, Business Architect, Analyst Developer, Risk Manager, Head of Process Management, Chief Architect, Solution Architect, EA Consultant and Applications Architect/Developer.

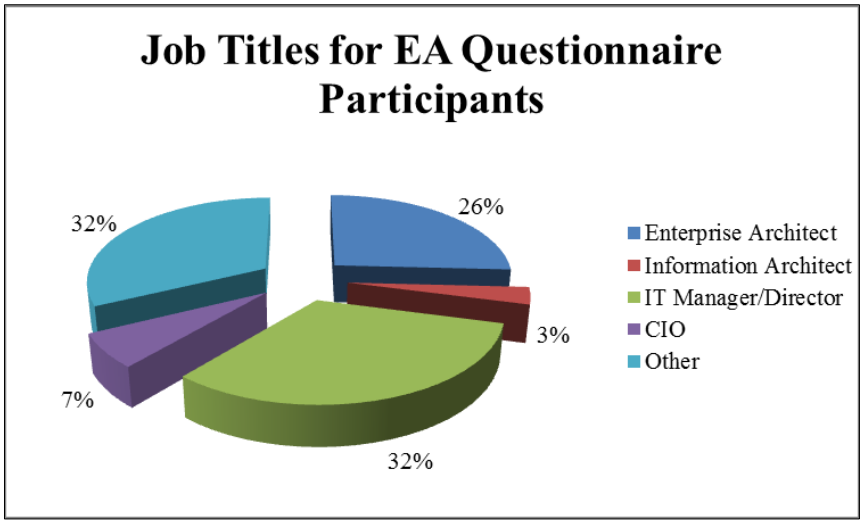


Figure 5-4: Job Titles for EA Questionnaire Participants

The participants had to select the number of years their organisations had been using an EA programme (Figure 5-5). The majority of the participants (n = 11) selected the responses that their organisations had been using an EA for 11 to 16 years. Ten participants (32%) selected 0 to 5 years and nine (29%) selected the interval of five to 10 years of having an EA programme. Only one participant, which is a major bank in South Africa, selected that their organisation has been using an EA programme for more than 17 years.

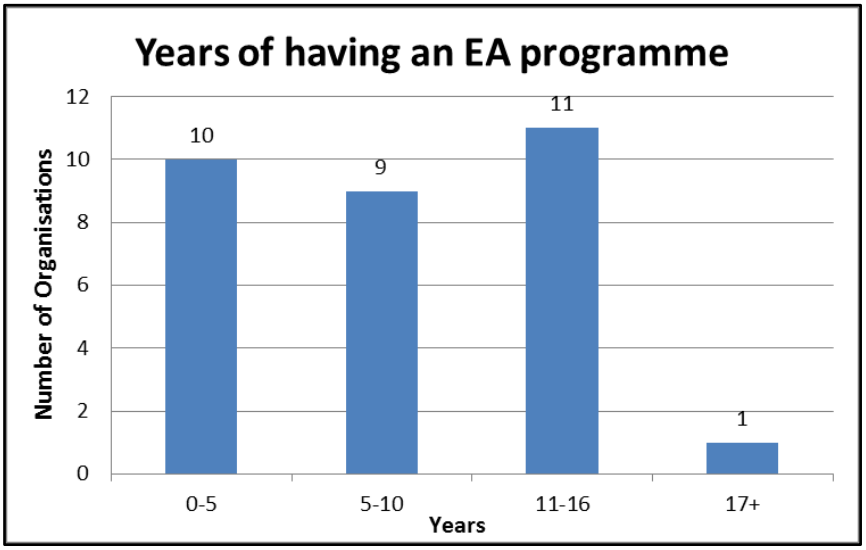


Figure 5-5: Number of years of having an EA Programme

The EA questionnaire consisted of many questions which were designed using a 5-point Likert scale, as well as list and category questions. This gave the participants the opportunity to rate and select the appropriate options for the various items in the questionnaire (Sekaran and Bougie, 2009).

5.4.1 Enterprise Architecture Questionnaire Quantitative Results

The participants were asked what the status of their current EA programme was and 61% (n = 19) selected that they have an EA programme in place in their organisation (Table 5-6). Another six (19%) participants said that his/her organisations were expanding their EA programmes. One participant said that their organisation had an EA programme in the past but currently did not have one now. Five participants selected "Other" as an option for their EA programme status, saying:

- *"EA not in place - more solution architecture orientated"* (n = 1);
- *"EA is not a separate role but rather integrated into existing roles"* (n = 1);
- *"…is a federated business with many different businesses. We don't over engineer"* (n = 1);
- *"We have an EA division that provides outsourced services to clients"* (n = 1); and
- *"Business area with EA initiatives, but not a formal programme"* (n = 1).

Table 5-6: Status of EA Programme

Status of EA programme	**n**	**%**
My organisation has an EA programme	19	61
My organisation is currently expanding our EA programme	6	19
My organisation had an EA programme in the past but does not have one now	1	3
Other	5	16
Total	**31**	**100**

The participants indicated which EA components were used in their organisations (Table 5-7). The Application and Technology architectures are used by the majority (87%) of participants. The Business and Information architectures are used by 81% (n = 25) of the participants. Some of the participants indicated that their organisations also make use of other EA components such as Security Architecture (n = 3), Solution Architecture (n = 1) and People Architecture (n = 1).

Table 5-7: EA Components used in Organisation

EA Component	**Yes**	**No**	**Totals**
	n	**n**	**n**
Business Architecture	25 (81%)	6 (19%)	**31 (100%)**
Information Architecture			
Application Architecture	27 (87%)	4 (13%)	**31 (100%)**
Technology Architecture			
Other EA Components Listed	**Yes**		
	n		
Security Architecture	3		
Solution Architecture	1		
People Architecture	1		

Figure 5-6 illustrates the organisations which take into account environmental information when designing their EA. A 5-point Likert scale was used whereby 1 indicates Strongly Disagree and 5 indicates Strongly Agree. Thirteen (42%) organisations Agree or Strongly Agree that they do take into account environmental information when designing their EA. The other participants 32% (n = 10) either Disagree or Strongly Disagree that they do take into account environmental information when designing their EA.

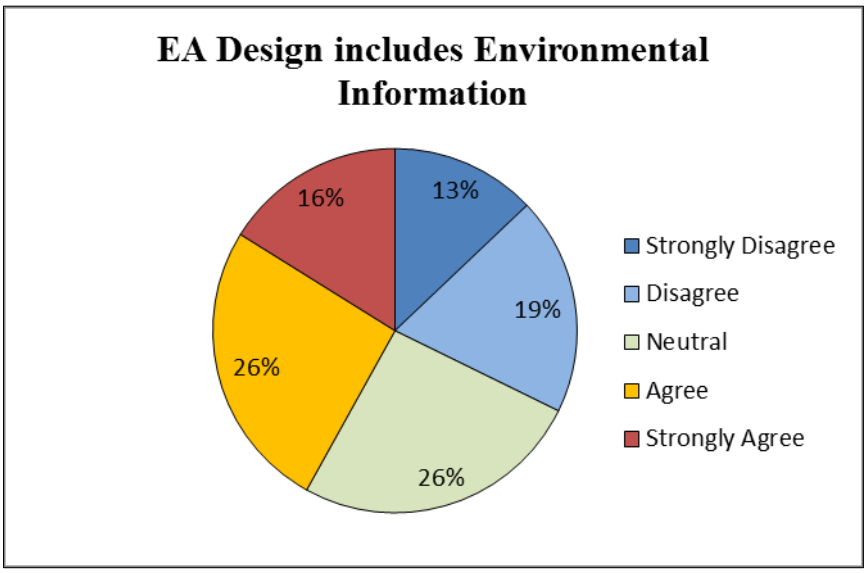


Figure 5-6: EA Design Incorporating Environmental Information

Table 5-8 shows the EA objectives ranked on their mean ratings. Based on the outcome of the reported inferential tests the EA objectives are grouped into two significant groups (Rank 1 to 2) are:

- Group 1: EA Objectives 1 to 13 with no significant difference between EA objective 1 "*Improve risk management"* and any of the other EA objectives (2 to 12) in this group; and
- Group 2: EA Objective 14 "*Include/improve environmental concerns"* is the only EA objective with a mean rating significantly less than that of EA objective 1 "*Improve risk management"*.

The four highest rated EA objectives are shown in bold-typeface (Table 5-8), and "*Improve risk management*" (μ = 4.10) was rated highest, followed by "*Improve IT Governance*" (μ = 4.06), "*Support system integration*" (μ = 4.03) and "*Improve enterprise decision making*" (μ = 4.03). The three EA objectives which had the lowest mean ratings are "*Ensure continuity of organisational knowledge*" (μ = 3.71), "*Support outsourcing initiatives*" (μ = 3.32) and "*Include/Improve environmental concerns*" (μ = 3.10).

Table 5-8: EA Objectives for the Organisations (n = 31)

EA Objectives	Rank	Mean	SD	Inferential Test			
				EA Objectives Compared	*t*-value	p-value	Cohen's *d*
1 Improve risk management	1	4.10	1.01	-	-	-	-
2 Improve IT Governance	1	4.06	1.03	1 & 2	0.21	.416	-
3 Support system integration	1	4.03	1.14	1 & 3	0.36	.361	-
4 Improve enterprise decision-making	1	4.03	1.17	1 & 4	0.35	.365	-
5 Business efficiency/transformation	1	4.00	1.00	1 & 5	0.68	.250	-
6 Promote Technical Infrastructure	1	3.97	1.28	1 & 6	0.56	.290	-
7 Reduce operating costs	1	3.97	1.22	1 & 7	0.85	.201	-
8 Improve technical integrity	1	3.94	1.15	1 & 8	0.84	.203	-
9 Increase effectiveness of audit Compliance	1	3.90	0.91	1 & 9	1.18	.123	0.21
10 Improve data integrity	1	3.87	1.28	1 & 10	1.37	.091	0.25
11 Reduce technical complexity	1	3.74	1.32	1 & 11	2.25	.016	0.40
12 Ensure continuity of organisational knowledge	1	3.71	1.01	1 & 12	2.55	.008	0.46
13 Support outsourcing initiatives	1	3.32	1.33	1 & 13	2.76	.005	0.49
14 Include/Improve environmental concerns	2	3.10	1.35	1 & 14	4.95	.000**	*0.89(Large)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

Figure 5-7 illustrates the frequency distribution of the EA objectives. The rating scale in this case was grouped into three groups: Negative, Neutral and Positive. The lower and upper values[1] selected for the three groups are Negative [1 to 2.6.), Neutral [2.6 to 3.4], and Positive (3.4 to 5]. These groups and values will be referred to throughout this study where applicable for the grouping of any 5-point Likert scale.

The objective with the highest frequency count (n = 26; 84%) was "*Improve enterprise decision-making*" in the positive range. This confirms the studies of Chen *et al.* (2008) and Schekkerman (2011b) which reported improved enterprise decision-making as a key objective of EA. "*Include/Improve environmental concerns*" was the objective with the lowest frequency count (n = 13; 42%) in the positive range as well as the highest frequency count (n= 9; 29%) in the negative range.

[1] [Greater than or equal to;
) Less than.

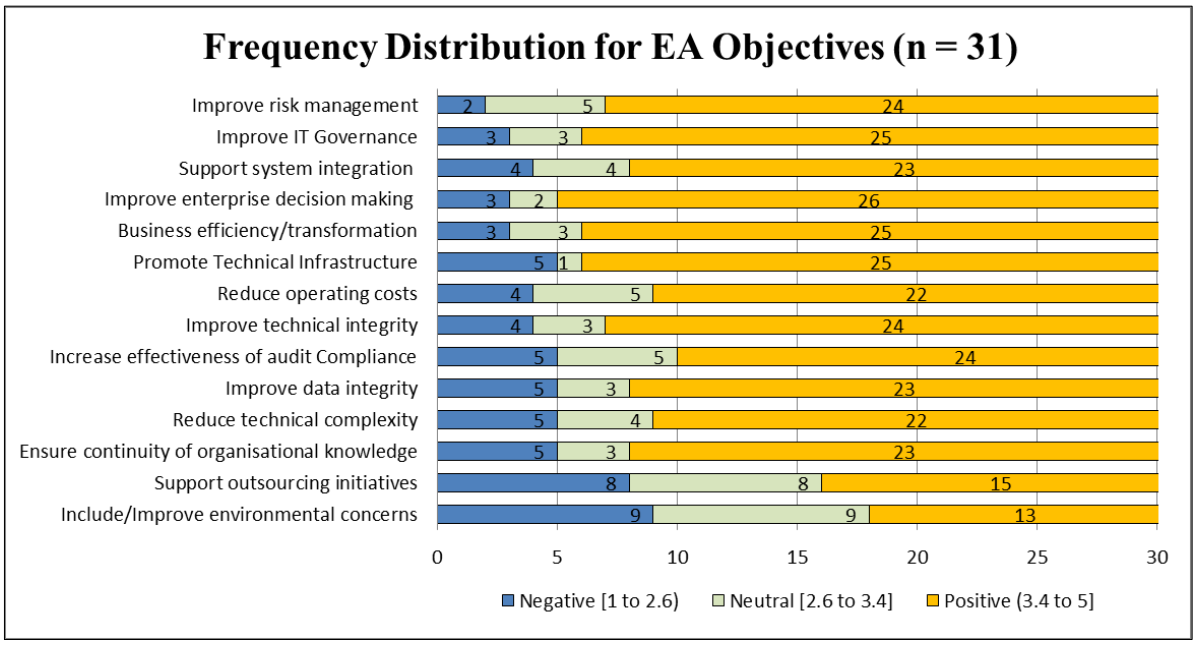


Figure 5-7: Frequency Distribution for EA Objectives

Several benefits of EA were identified in literature (Table 3-2) and included in the EA questionnaire. Inferential tests were performed to confirm any significant difference between the EA benefits (Table 5-14). The EA benefits were rated using the mean for each benefit. Based on the outcome of the reported inferential tests the EA benefits are grouped in two significant groups (Rank 1 to 2) are:

- Group 1: The EA benefits 1 to 9 had no significant difference between EA benefit 1; "*System integration*" and the other EA benefits 2 to 8; and
- Group 2: EA benefit 10 "*Business governance*" is the only benefit with a mean rating significantly less than that of EA benefit 1 "*System integration*".

The top three rated EA benefits are shown in bold-typeface (Table 5-9). System integration was the benefit which had the highest mean value (μ = 4.03) for EA adoption. The second highest benefit for EA adoption was "*IT governance*" (μ = 3.90), followed by "*Team follows a common technical infrastructure*" (μ = 3.87). This supports studies (Chen *et al.*, 2008; Gravesen, 2012; Ross, 2006; Winter and Schelp, 2008) reporting these EA benefits as the most commonly achieved benefits of using an EA.

The three benefits of EA which had the lowest mean values were *"Data integrity"* (μ = 3.61), "*Continuity of organisation knowledge"* (μ = 3.55) and "*Business governance*" (μ = 3.39). These benefits correspond with the rating of each of the EA benefits using the frequency counts (Figure 5-8).

Table 5-9: EA Benefits for Organisations (n = 31)

EA Benefits	Rank	Mean	SD	Inferential test			
				EA Benefits Compared	*t*-value	p-value	Cohen's *d*
1. System integration	1	4.03	1.14	-	-	-	-
2. IT governance	1	3.90	1.11	1 & 2	0.94	.177	0.17
3. Team follows a common technical infrastructure	1	3.87	1.15	1 & 3	1.00	.163	0.18
4. Business efficiency	1	3.84	1.27	1 & 4	1.00	.163	0.18
5. Audit compliance	1	3.84	1.00	1 & 5	0.95	.176	0.17
6. Risk management	1	3.84	0.97	1 & 6	1.10	.140	0.20
7. Technical integrity	1	3.84	0.90	1 & 7	1.65	.055	0.30
8. Data integrity	1	3.61	1.33	1 & 8	2.53	.008	0.45
9. Continuity of organisation knowledge	1	3.55	1.18	1 & 9	2.54	.008	0.46
10. Business governance	2	3.39	1.02	1 & 10	3.32	.001**	*0.60 (Moderate)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

Figure 5-8 illustrates the frequency distribution for the EA benefits in terms of the range for negative, neutral and positive frequency counts. "*System integration*" (n = 26) has the highest frequency count in the positive range, followed by "*IT governance*" (n = 25). "*Continuity of organisation knowledge*" was the benefit with the second lowest frequency count (n = 18) in the positive range, followed by "*Business governance*" with the lowest frequency count (n = 17).

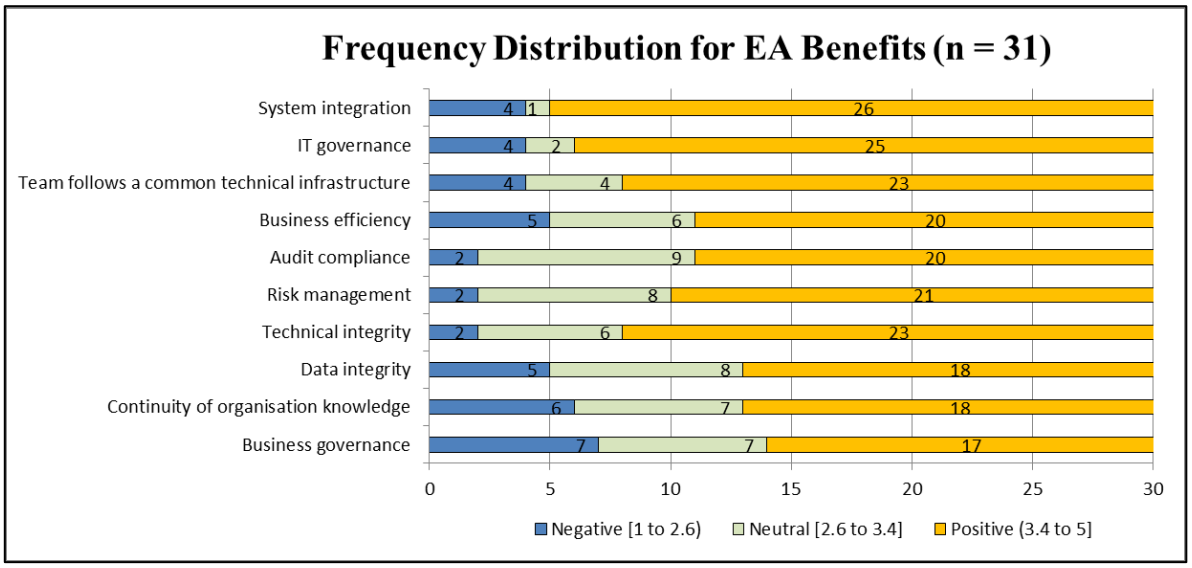


Figure 5-8: Frequency Distribution for EA Benefits

Table 5-10 shows the EA models ranked on their mean ratings. Based on the outcome of the reported inferential tests the EA models are grouped in two significant groups (Rank 1 to 2) are:

- Group 1: EA models 1 to 7 with no significant difference between EA model 1 "*Business architecture model*" and any of the other EA models (2 to 7) in this group; and
- Group 2: EA model 8 "*Enterprise use case model*" is the only model with a mean rating significantly less than that of EA model 1 "*Business architecture model*".

Table 5-10 also shows the three highest rated EA models in bold-typeface are: "*Business architecture model*" (μ = 3.90), "*Security models*" (μ = 3.90) and "*Enterprise business process model*" (μ = 3.81). This support the studies (Alexopoulou *et al.*, 2010; Ekstedt and Sommestad, 2009; Orr *et al.*, 2005) showing that these models are still frequently used for EA modelling purposes. The three EA models which had the lowest mean ratings are "*Deployment models*" (μ = 3.55), "*Detailed enterprise data model (EDM)*" (μ = 3.45) and "*Enterprise use case model*" (μ = 3.13).

Table 5-10: EA Models Used in Organisations (n = 31)

EA Models	Rank	Mean	SD	Inferential Test			
				EA Models Compared	*t*-value	p-value	Cohen's *d*
1 Business architecture model	1	3.90	1.27	-	-	-	-
2 Security models	1	3.90	1.14	1 & 2	0.00	.500	-
3 Enterprise business process model	1	3.81	1.25	1 & 3	0.62	.270	-
4 High-level conceptual data model	1	3.65	1.20	1 & 4	1.22	.117	0.22
5 Component model	1	3.58	1.29	1 & 5	1.41	.085	0.25
6 Deployment models	1	3.55	1.29	1 & 6	1.46	.078	0.26
7 Detailed enterprise data model (EDM)	1	3.45	1.29	1 & 7	1.75	.045	0.31
8 Enterprise use case model	2	3.13	1.28	1 & 8	3.36	.001**	*0.60 (Moderate)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

The participants were asked which types of models their organisations use to design their EA (Figure 5-9). "*Security models*" has the highest frequency count (n = 22) in the positive range which is 70% of the respondents who said they use these models when designing their EA. "*Enterprise use case model*" are the least used models with the lowest frequency count (n = 10; 33%) in the positive range and the highest frequency count (n = 10) in the negative range.

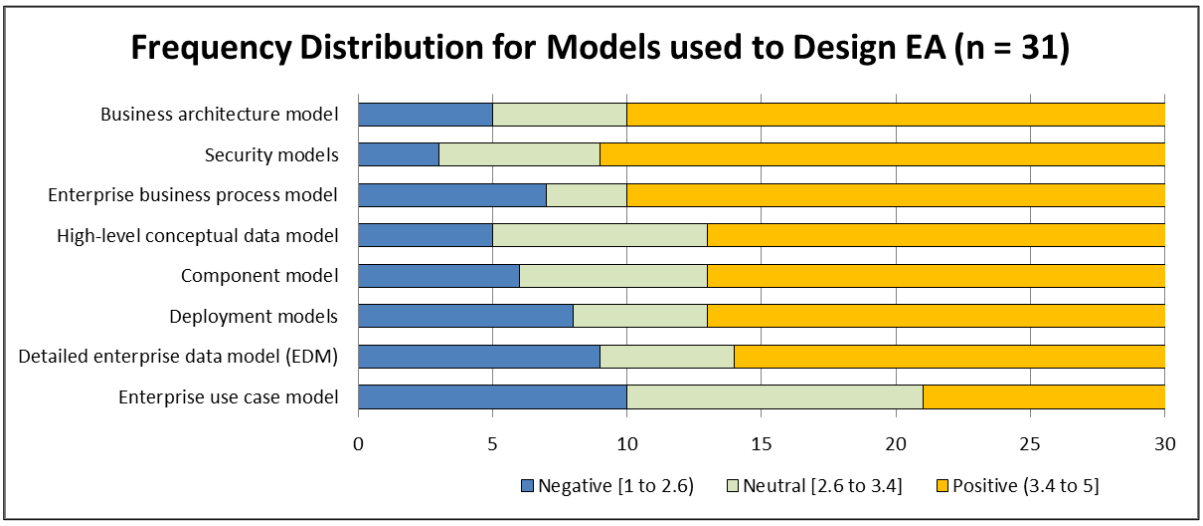


Figure 5-9: Frequency Distribution for EA Models

Two of the participants reported that other EA models were also used in their organisations. One organisation reported using: strategy models, end-to-end process models, functional decomposition models, capability models. The other organisation reported using application landscape and capability business models.

The results revealed that various EA frameworks are implemented in the participating organisations (Table 5-11). The EA frameworks were ranked on their mean ratings. Based on the outcome of the reported inferential tests the EA frameworks are grouped in two significant groups (Rank 2 to 3) are:

- Group 2: There is no significant difference between EA frameworks 2 and 3. However EA framework 2 "*Zachman*" has a mean rating significantly less than that of EA framework 1 namely, The Open Group Architectural Framework "*TOGAF*"; and
- Group 3: EA framework 4 namely, Ministry of Defense Architecture Framework "*MODAF*" also has a mean rating significantly less than that of EA framework 2 "*Zachman*".

The EA framework which is ranked highest in terms of its mean rating is "*TOGAF*" (μ = 3.52) with the highest frequency count (n = 17) in the positive range (Table 5-11). This supports the study by RealIRM (2007) showing an increase on a global scale amongst the large South African organisations adopting TOGAF. This also supports the study of Josey (2013) which reports that South Africa is seventh globally in terms of the number of TOGAF certifications. The EA framework which is least used amongst the participating organisations is MODAF (μ = 1.61) and an 81% (n = 25) in the negative range.

Table 5-11: EA Frameworks Adopted in Organisations (n = 31)

					Frequency Distribution			Inferential Test			
EA Framework	**Rank**	**Mean**	**SD**		**Negative [1 to 2.6)**	**Neutral [2.6 to 3.4]**	**Positive (3.4 to 5]**	**EA Framework Compared**	***t*-value**	**p-value**	**Cohen's *d***
					n	**n**	**n**				
1 TOGAF	2	3.52	1.43		8 (26%)	6 (19%)	17 (54%)	-	-	-	-
2 Zachman	2	3.19	1.22		7 (23%)	12 (39%)	12 (39%)	1 & 2	2.16	.020*	*0.39 (Small)*
3 Hybrid frameworks	2	3.06	1.55		12 (39%)	4 (13%)	15 (49%)	2 & 3	0.31	.378	-
4 MODAF	3	1.61	0.80		25 (81%)	6 (19%)	0 (0%)	2 & 4	5.95	.000**	*1.07 (Large)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

Fifteen organisations also listed that they create their own hybrid EA framework. Ten of these organisations (n = 10) supplied information regarding the frameworks used. One of the ten organisations (n = 1) use these frameworks but as a service provider. The three types of frameworks reported by the other nine organisations were:

- Enterprise process map (n = 1);
- Internal organisational created frameworks (n = 2); and
- Hybrids of TOGAF and Zachman and Gartner frameworks (n = 6).

The EA modelling notations used in the participating organisations were rated by using the mean value (Table 5-12). The *t* test and Cohen's *d* inferential tests were performed to test for significant difference between these models, but yielded no significance and all EA modelling formed part of one grouping (Rank 1). The highest rating was "*Business Process Modelling Notation (BPMN)*" (μ = 3.52), and for the option "*We have our own internal standard notations*" (μ = 2.77).

Table 5-12: EA Modelling Notations Used in Organisations (n = 31)

EA Modelling Notations	Rank	Mean	SD	Inferential test			
				EA Modelling Notations Compared	*t*-value	p-value	Cohen's *d*
1. Business Process Modelling Notation (BPMN)	1	3.52	1.31	-	-	-	-
2. Industry specific modelling language	1	3.45	1.36	1 & 2	0.27	.395	-
3. Unified Modelling Language (UML)	1	3.26	1.34	1 & 3	1.44	.080	0.26
4. We have our own internal standard notations	1	2.77	1.54	1 & 4	2.03	.026	0.37

* p-value ≤ 0.05; ** p-value ≤ 0.01

The participants had to identify which of these modelling notations are applied in their organisations when designing their EA (Figure 5-10). They had to select their choices using a 5-point Likert scale with the 1 representing Never and 5 representing Always. Figure 5-10 shows the highest frequency count were for the modelling notation "*BPMN*" (n =20) in the positive range, followed by "*Industry specific modelling language*" with the second highest frequency count (n = 18) in the positive range. The highest frequency count in the negative range was for the option "*We have our own internal standard notations*" (n=14).

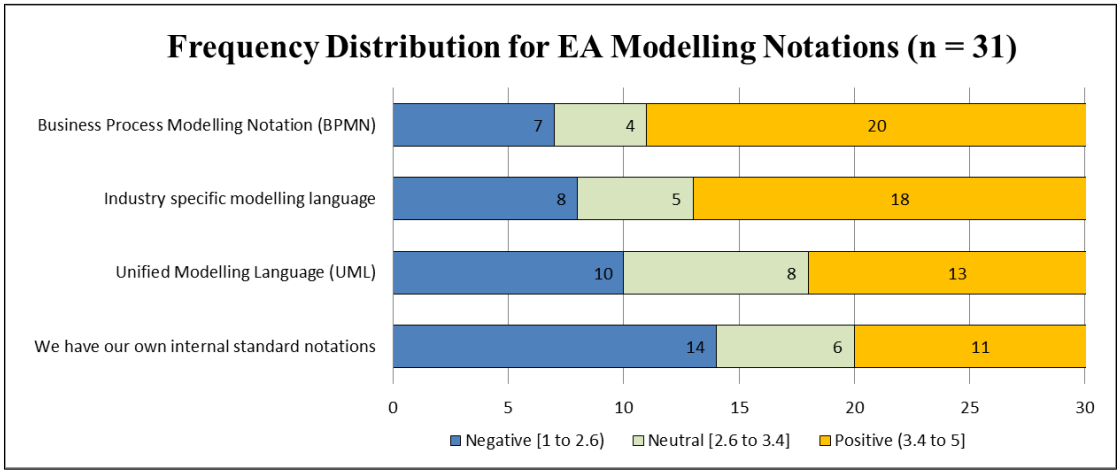


Figure 5-10: Frequency Distribution for EA Modelling Notations

Eleven participants reported that they "*have our own internal standard notations*" (n=11). Only seven participants specified which modelling notations their organisations use, namely:

- "*Based on programme being executed for stakeholder*" (n= 1)*;*
- "*Various modelling notations which might be hybrids*" (n= 1)*;*
- "*Industry specific notation*" (n= 1)*;*
- "*Architecture of Integrated Information Systems (ARIS) with customised template*" (n = 2)*;*
- "*Organisation-specific nomenclature and standards for Process, Data and Application Modelling*" (n= 1)*;* and
- "*Flow charts. Both UML and BPMN are used in a design context but not an EA context*" (n= 1).

The EA technologies were rated by using the mean for each technology (Table 5-13). Based on the outcome of the reported inferential tests the EA technologies are grouped in two significant groups (Rank 1 to 2) are:

- Group 1: There is no significant difference between EA technologies 1 to 2.; and
- Group 2: EA technology 3 "*Common Frameworks*" has a mean rating significantly less than that of EA technology 1 "*Business Process Management (BPM)*". There is also no significant difference between EA technology 3 "*Common Frameworks*" and the other EA technologies 4 to 7.

The highest three rated EA technologies are shown in bold-typeface that are used in participating organisations are "*BPM*" (μ = 3.97), "*Components*" (μ = 3.61) and "*Common Frameworks*" (μ = 3.58). The lowest two EA technologies rated in terms of the mean for each are: "*Product Line Architecture*" (μ = 3.26), and "*Software as a Service (SAAS)*" (μ = 3.06).

Table 5-13: EA Technologies Used in Organisations (n = 31)

EA Technologies	Rank	Mean	SD	Inferential test			
				EA Technologies Compared	*t*-value	p-value	Cohen's *d*
1. Business Process Management (BPM)	1	3.97	1.11	-	-	-	-
2. Components	1	3.61	0.99	1 & 2	1.65	.055	0.30
3. Common Frameworks	2	3.58	1.15	1 & 3	2.11	.022*	*0.38 (Small)*
4. Service Oriented Architecture (SOA)	2	3.48	1.31	3 & 4	0.44	.331	-
5. Cloud Computing	2	3.29	1.27	3 & 5	1.36	.092	0.24
6. Product Line Architecture	2	3.26	1.18	3 & 6	1.77	.043	0.32
7. Software as a Service (SAAS)	2	3.06	1.34	3 & 7	2.33	.013	0.42

* p-value ≤ 0.05; ** p-value ≤ 0.01

The technology (Figure 5-11) used for EA by the organisations which had the highest frequency count in the positive range was "*BPM*" (n = 23). This confirms the study of Jensen *et al.* (2011) that BPM can be used with EA for better business operations. The second highest rated technology was "*SOA*" (n = 19) followed by "*Common Frameworks*" (n = 18). The two technologies which had the lowest frequency counts in the negative range were, "*SAAS*" (n = 10) and "*Cloud Computing*" (n = 10).

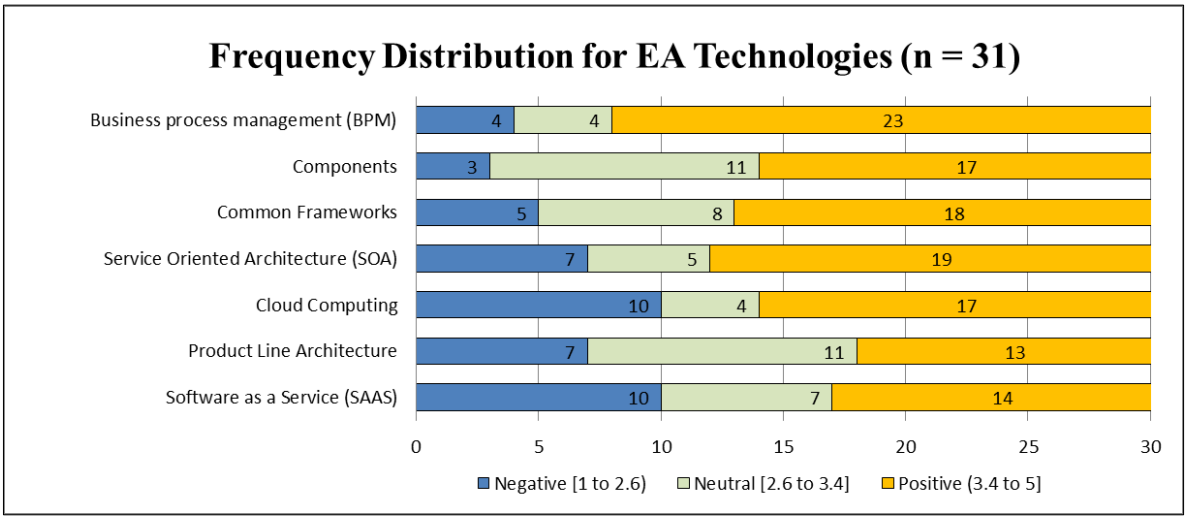


Figure 5-11: Frequency Distribution for Technologies used for EA

5.4.2 Enterprise Architecture Questionnaire Qualitative Results

The EA questionnaire included some open-ended questions, which gave the participants an opportunity to give qualitative open-ended feedback on the various issues covered in the questionnaire. The participants were asked to list the benefits and challenges which they had experienced with EA adoption in their organisations. The responses were analysed by using Atlas.Ti, a qualitative data analysis tool. The benefits that were listed were coded and further categorised into five main categories by using the content analysis approach (Table 5-15). The six main categories were identified from theory (Lucke *et al.*, 2010) and were used to confirm the categories that existed within the coding process (Sekaran and Bougie, 2009). These categories were: Management, Complexity, Semantic benefits, Representation, Standardisation and Technical infrastructure.

Thirty participants (n = 30) listed benefits that they have experienced with EA. Table 5-15 lists the codes identified together with sample responses from participants. A list of 26 codes were created from these benefits and each code was assigned a frequency count (f) representing the number of times the participants listed the code and those frequency counts which were ranked highest are represented in bold-typeface (Table 5-14). The two codes that had the highest frequency counts for EA benefits were "*commonality*" (f = 7) and "*standardisation*" (f = 6) which are grouped together under the standardisation category (bold-typeface in Table 5-14). These benefits with the highest frequency counts were also listed in terms of the highest ranked quantitative benefits results (Table 5-9), as some of the example responses listed (Table 5-14) for these benefits were "*common framework*" and "*standardisation of technology infrastructure*". The quantitative EA benefit "*Team follows a common technical infrastructure*" (Table 5-9) is an example of the qualitative EA benefit "*commonality*" as well as the quantitative EA benefit "*System integration*" is an example of the qualitative EA benefit "*standardisation*". Therefore triangulation of quantitative results was achieved.

Table 5-14: EA Benefits Classified by Categories

Categories	Code and frequency (f) counts	Examples of the responses
Management	governance capability (f = 4)	*IT governance;* *improved good governance capability*
	process improvements (f = 3)	*good process flow;* *business architecture models used by business;* *to determine top priority process*
	decision-making (f = 2)	*insight into technical landscape, which helps in decision-making*
	alignment (f = 1)	*alignment*
	change management (f = 1)	*change management was made a whole lot easier and quicker*
	enhanced productivity (f = 1)	*enhanced employee productivity*
	revenue increases (f = 1)	*revenue increases*
Standardisation	**commonality (f = 7)**	*common framework;* *common view on managed evolution business-IT alignment*
	standardisation (f = 6)	*standardisation of technology infrastructure;* *standardisation of processes & systems*
	integration (f = 4)	*systems integration;* *integrated components and operating models;* *data integration*
Complexity	respond (f = 5)	*project completion;* *our EA enable us to respond speedily to during;* *customer engagement*
	reduced complexity (f = 3)	*simplification of processes*
	reduced cost (f = 3)	*cost savings*
	risk management (f = 3)	*reduction of risks and technical debt harvesting of older technologies*
	reduced duplication (f = 1)	*less duplication*
Semantic benefits	understanding (f = 2)	*better understanding of our technology;* *landscape; understanding the impact of change to a business process*
Representation	efficiency and effectiveness (f = 5)	*improved reliability and efficiency;* *transactional efficiency*
	quality (f = 2)	*quality of solutions based on the underlying EA*
	visibility(f = 2)	*insight into technical landscape;* *clear future application landscape enabling rationalisation*
	innovative solution (f = 1)	*innovative solution*
	integrity (f = 1)	*data integrity*
Technical infrastructure	consistency (f = 1)	*improved consistency*
	convergence (f = 1)	*convergence of systems and data across the various verticals*
	re-usable services and components (f = 1)	*re-usable services and components*
	repeatability (f = 1)	*repeatability of solutions based on the underlying EA*
	sustainable designs (f = 1)	*more sustainable designs*

The participants also listed the challenges that their organisations experienced using an EA. The challenges were analysed and 16 codes were developed from the list of challenges (Table 5-15). The codes were then assigned to five main categories identified within literature (Lucke *et al.*, 2010).

These categories were Management, Complexities, Semantic benefits, Representation, and Insufficient resources. The codes were assigned frequency counts (f) for the number of times the same code appeared for different participants and those frequency counts which were ranked highest are represented in bold-typeface (Table 5-15). The codes with the highest frequency counts were "*resourcing and management buy-in*" (f = 11), "*training and education*" (f = 7) and "*implementation*" (f = 5). Table 5-15 also shows the EA challenges codes and the examples listed of the challenges experienced by the participating organisations. The appropriate examples are mapped to the codes which were derived from the challenges listed by the participants.

Table 5-15: EA Challenges Classified by Categories

Categories	Codes	Examples of the responses
Management	resourcing and management buy-in **(f = 11)**	*resourcing and management buy-in;* *difficult to sell EA benefits;* *difficulty to introduce the concept through having a clear business case*
	quantifying benefits and value (f = 3)	*quantifying value gained is extremely difficult*
	ownership (f = 2)	*executive ownership*
	adoption (f = 2)	*adoption across diverse business units*
	alignment (f = 1)	*ensuring continued alignment with organisational and external changes*
	conflicts between departments (f = 1)	*conflict between business architects and process re-engineering departments*
	lack strategic vision (f = 1)	*strategic vision lacking*
	political interconnectedness (f = 1)	*political interconnectedness based on strength of EA and how organisation tend to use it*
Complexities	changing technology (f = 2)	*rapidly changing technology and software make corporate standards obsolete in 2-3 years*
	maintenance (f = 3)	*the focus is now on maintaining the EA; IT does in some cases add overhead to maintain and extend the EA as part of incremental improvements*
	resistance to change (f = 2)	*resistance to change when new SOA design and development practices were introduced;* *inflexibility to change by other senior employees*
	increased costs (f = 1)	*increased expenditure requirement for a larger IT budget*
Semantic problems	training and education **(f = 7)**	*training and education as part of the overall EA process was designed to overcome inherent understanding and application of the architecture;* *learning;* *EA need to be understood by those using it*
	communication (f = 2)	*effective communication of strategy*
Representation	keep models up to date (f = 1)	*difficult to keep models up to date*
Insufficient resources	implementation **(f = 5)**	*implementation of the utility model as well as using a new methodology;* *not always possible to implement with legacy applications and systems*
	capacity to develop (f=1)	*capacity to develop all the required artefacts and business adoption*

5.5 Environmental Information Management Questionnaire Participant Profile

Both males (77%) and females (23%) completed the EIM questionnaire. Five participants (16%) were of the age category 26-35, 39% were of the ages 36-45, and 42% were of the age category 46-55 (Table 5-16).

Table 5-16: Biographical Information

Gender	**n**	**%**
Male	24	77%
Female	7	23%
Total	**31**	**100%**
Age	**n**	**%**
26-35	5	16%
36-45	12	39%
46-55	13	42%
56+	1	3%
Total	**31**	**100%**

The majority of the participants (36%) selected "*Other*" as the option for job titles Figure 5-12. The job titles for the "*Other*" selection were: ICT Audit Director, Senior Consultant, Business Architect, Analyst Developer, Head of Process Management, Group Head Investor Relations and Sustainability, Group Head: Sustainability, EA Consultant, CIO and Applications Architect and Developer. Eight participants (26%) also selected that their job titles were as "*Information Architect*" and another 26% (n=8) said that their job titles were "*IT-Manager/Director*".

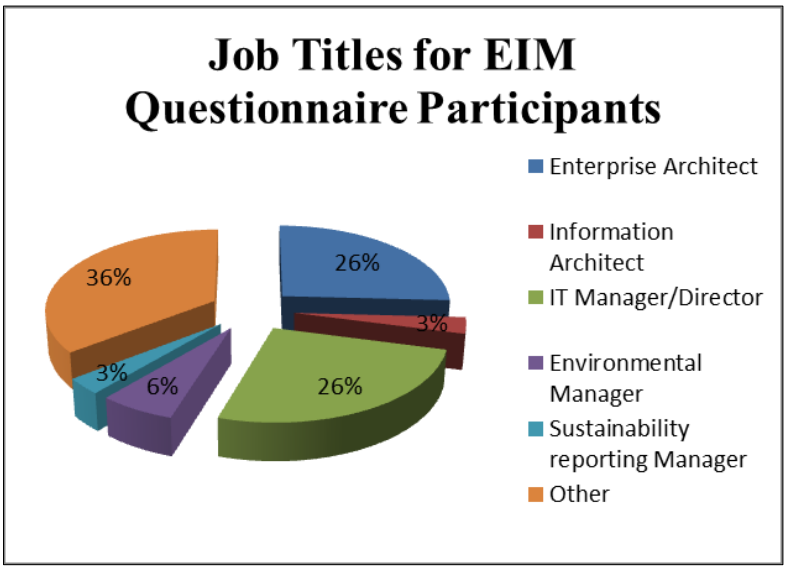


Figure 5-12: Job Titles for EIM Questionnaire Participants

5.5.1 Environmental Information Management Questionnaire Quantitative Results

The majority (62%) of the participating organisations "*practices sustainability reporting internally and provide a sustainability report to external stakeholders*" (Table 5-17). Ten of the participants (32%) selected that their organisations "*practices sustainability reporting internally only*". The one participant who selected "*Other*" as an option said that they do not deal with the sustainability reporting matters in their department, as their department deals with the EA aspect and that environmental sustainability matters are managed outside of the EA programme.

Table 5-17: Status of Sustainability Reporting

Status of Sustainability Reporting	n	%
My organisation does report on sustainability matters	1	3%
My organisation practices sustainability reporting internally only	10	32%
My organisation practices sustainability reporting internally as well as provide a sustainability report to external stakeholders	19	62%
Other	1	3%
Total	**31**	**100%**

The primary target audience for sustainability reporting (Table 5-18) and the most frequently selected audience were "*Customers*" (71%), "*Employees*" (68%) and "*Government*" (68%) chosen by the majority of participants. Two of the six participants who selected "*Other*" as an option said that *"Shareholders*" is also part of their target audience. Another said that "*prospective clients*" forms part of their target audience and the other three participants said that they have "*none*" (n = 2) or that they "*did not know"* (n = 1) of any.

Table 5-18: Target Audience for Sustainability Reports (n = 31)

Target Audience	Yes		No	
	n	%	n	%
Customers	22	71	9	29%
Employees	21	68%	10	32%
Government (legislation compliance)	21	68%	10	32%
Suppliers	20	65%	11	35%
International Organisations/Partners	19	61%	12	39%
Non-Governmental Organisation (NGO)	16	52%	15	48%
All the above	15	48%	16	52%
Other	6	19%	25	81%

The closed-ended questions on the EIM questionnaire were constructed using a 5-point Likert scale where the participants had to rate the questions. The participants had to rate whether their organisation's processes included environmental, social and economic reporting with the lowest value (1) being Strongly Disagree and the highest value (5) being Strongly Agree.

The environmental sustainability objective 1 "*Improve sustainability reporting practices*" was compared to the other objectives 2 to 5 to test for any significant differences between these objectives and yielded no significance (Table 5-19). Therefore these objectives were grouped in the same significant group (Rank 1).

Table 5-19 lists the ratings for the environmental sustainability objectives according to the mean values. The top three rated sustainability reporting objectives are shown in bold-typeface. The objective to "*Improve sustainability practices*" was rated highest (μ = 3.58) followed by *"Improve dialogue with stakeholders about sustainability*" (μ = 3.55). *"Initiate programmes to eliminate hazardous substances in materials and parts purchased*", was rated lowest (μ = 3.26) by the participants.

Table 5-19: Environmental Sustainability Objectives (n = 31)

Environmental Sustainability Objectives	**Rank**	**Mean**	**SD**	**Inferential test**			
				Environmental Sustainability Objectives	***t*-value**	**p-value**	**Cohen's *d***
1. Improve sustainability reporting practices	1	3.58	1.15	-	-	-	-
2. Improve dialogue with stakeholders about sustainability	1	3.55	1.12	1 & 2	0.27	.393	-
3. Improve sustainability marketing	1	3.52	1.09	1 & 3	0.42	.338	-
4. Increase sustainable use of natural resources (e.g. land, forests, animal and population.)	1	3.45	1.31	1 & 4	0.72	.237	-
5. Initiate programmes to eliminate hazardous substances in materials and parts purchased	1	3.26	1.26	1 & 5	1.62	.058	0.29

* p-value ≤ 0.05; ** p-value ≤ 0.01

The participants had to rate which environmental sustainability objectives (Figure 5-13) are evident in their organisations. The objective to "*Improve dialogue with stakeholders about sustainability*" (n = 20) and "*Improve sustainability marketing*" (n = 20) received the highest frequency counts and were both in the positive range. This confirms other studies (Deloitte and Touche, 2002; Speshock, 2010) which highlight these objectives as important. The second highest frequency count was for the objective "*Improve Sustainability Reporting practices*" (n = 19) in the positive range. Two participants also listed the following environmental sustainability objectives: "*Educating consumers about responsible use of alcohol*" (n = 1) and *"Reduce Electricity Waste, Energy-Efficient Locos, Best Practice Waste Management Processes*" (n = 1).

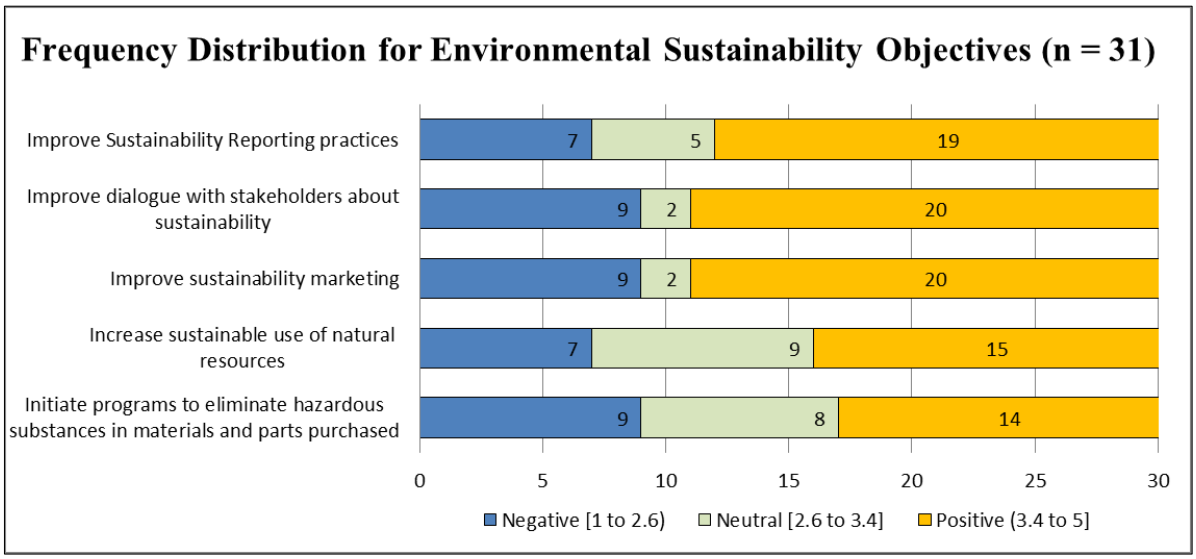


Figure 5-13: Environmental Sustainability Objectives

Inferential tests were performed to test for significant difference between the different types of sustainability reports (Table 5-20). The sustainability reporting type 1 "*Economic Reporting*" was compared to the other types of reports 2 to 3 and the only reporting type 2 "*Social Reporting*" had a mean rating significantly less than that of "*Economic Reporting*" type 1. These reports were grouped into one significant grouping (Rank 2). Table 5-20 also illustrates the ratings according to the mean value for the different types of sustainability reporting which are included in the participating organisations processes. "*Economic Reporting*" (μ = 4.68) received the highest rating and "*Environmental Reporting*" (μ = 3.61) the lowest rating.

Table 5-20: Reporting Included in Organisational Processes (n = 31)

Sustainability Reporting Type	**Rank**	**Mean**	**SD**	**Inferential test**			
				Sustainability Reporting Types Compared	***t*-value**	**p-value**	**Cohen's *d***
1. Economic Reporting	2	4.68	0.54	-	-	-	-
2. Social Reporting	2	4.03	0.95	1 & 2	3.65	.000**	*0.66 (Moderate)*
3. Environmental Reporting	2	3.61	1.33	1 & 3	1.89	.034	0.34

* p-value ≤ 0.05; ** p-value ≤ 0.01

Figure 5-14 shows that "*Economic Reporting*" seems to be the most popular process in the participating organisations processes with a frequency count (n = 30) in the positive range and "*Environmental Reporting*" the least popular with a frequency count (n = 20) in the positive range. This supports the study by Rea (2012) showing that the economic reporting response rate is much higher than the environmental reporting response rate.

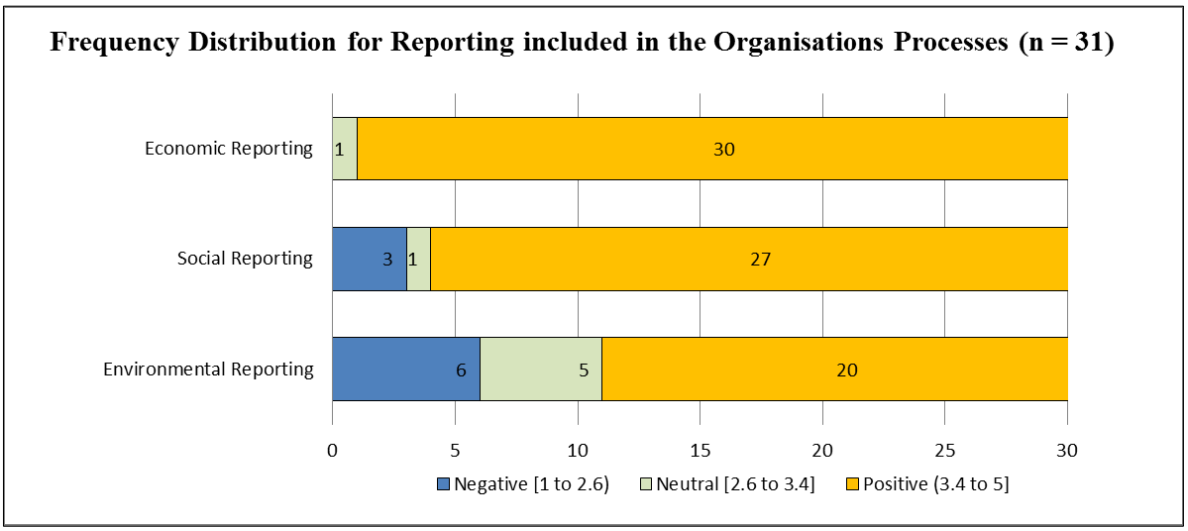


Figure 5-14: Reporting in Organisations

Table 5-21 shows the environmental sustainability reporting standards ranked on their mean ratings. Based on the outcome of the reported inferential tests the environmental sustainability reporting standards are grouped in two significance groups (Rank 1 to 2):

- Group 1: The environmental sustainability reporting standards 1 to 2 with no significant difference between the International Organisation for Standardisation "*ISO 14001*" and the Global Reporting Initiative "*GRI*" in this group; and
- Group 2: The environmental sustainability reporting standard namely, Environmental Management System "*EMS*" is the only standard with a mean rating significantly less than that of environmental sustainability reporting standard 1 "*ISO 14001*".

ISO 14001 rated first (μ = 3.26) according to the mean value for the different standards rated by the participants (Table 5-21). This supports the study (ISO, 2012) showing that South Africa has the most ISO 14001 certificates in the whole of Africa. GRI received the second highest rating (μ = 2.87) and EMS the lowest rating (μ = 2.84).

Table 5-21: Standards for Environmental Sustainability Reporting (n = 31)

Standards for Environmental Sustainability Reporting	Rank	Mean	SD	Inferential test			
				Standards for Environmental Sustainability Reporting Compared	*t*-value	p-value	Cohen's *d*
1. ISO 14001	1	3.26	1.46	-	-	-	-
2. GRI	1	2.87	1.50	1 & 2	1.40	.086	0.25
3. EMS	2	2.84	1.34	1 & 3	2.14	.020*	*0.39 (Small)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

Figure 5-15 illustrates that "*ISO 14001*" is the sustainability reporting standard which is mostly used amongst the participating organisations (n = 16), in the positive range. The GRI standard received the second highest frequency count (n = 11) in the positive range. The EMS standard had the lowest frequency count in the positive range (n = 9) and the highest in the negative range (n = 10). Five participants also listed other sustainability reporting standards namely:

- In-House reporting (n = 1);
- ISO 22000 and Publicly Available Specification (PAS) 220 (n = 1);
- ISO 20000 (n = 1);
- Carbon Disclosure Project (CDP) and the Johannesburg Stock Exchange Socially Responsible Investment Index (JSE SRI Index) (n = 1); and
- King III (n = 1).

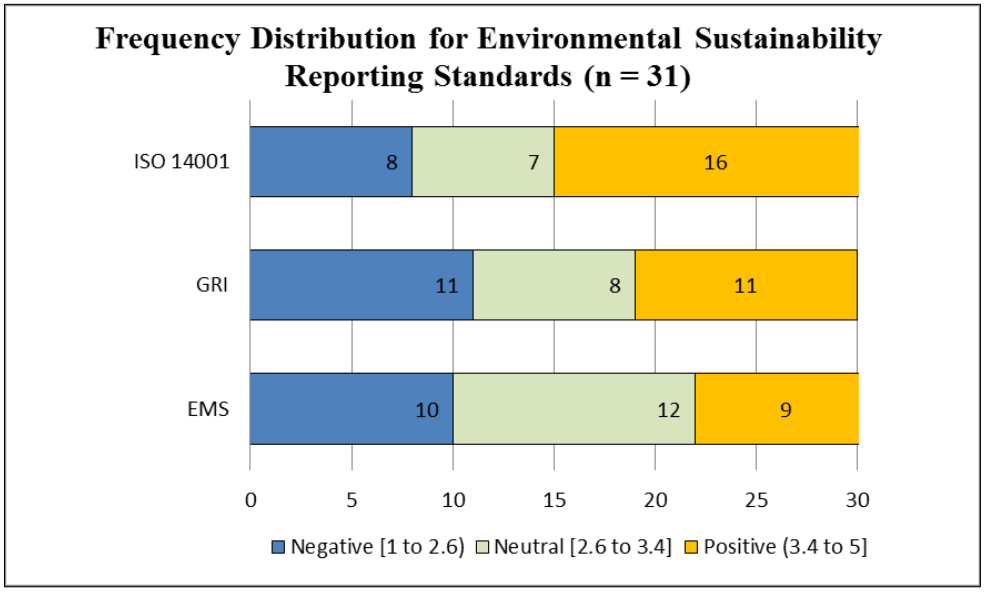


Figure 5-15: Standards for Environmental Sustainability Reporting

The stakeholder concern 1 "*Environmental issues*" was compared to the other issues 2 to 3 found in the participating organisations and the only stakeholder concern with a mean rating significantly less than that of concern 1"*Environmental issues*" is "*Social issues*" (Table 5-22). These stakeholder concerns were grouped into significant groupings (Rank 1 to 2).

Table 5-22 also shows the stakeholder concerns within the sustainability reporting process in order of importance to the participating organisations. "*Economic*" (n = 28) and "*Social*" (n = 28) issues with the highest frequency counts in the positive range and with mean values (μ = 4.42) and (μ = 4.26) respectively seems to be of great importance to organisations. "*Environmental*" issues was rated least with a frequency count in the positive range (n = 22) as well as with a mean value (μ = 3.61) in terms of importance amongst the participating organisations. This confirms the study of Rea (2012).

Table 5-22: Stakeholder Concerns in Terms of Importance to Organisations (n = 31)

				Frequency Distribution			Inferential test			
Stakeholder Concerns in Organisation	**Rank**	**Mean**	**SD**	**Negative [1 to 2.6)**	**Neutral [2.6 to 3.4]**	**Positive (3.4 to 5]**	**Stakeholder Concerns in Organisation Compared**	***t*-value**	**p-value**	**Cohen's *d***
				n	**n**	**n**				
1. Environme -ntal Issues	1	3.61	1.41	7 (22%)	2 (6%)	22 (71%)	-	-	-	-
2. Economic Issues	1	4.42	0.67	0 (0%)	3 (10%)	28 (90%)	1 & 2	1.40	.086	0.25
3. Social Issues	2	4.26	0.89	3 (10%)	0 (0%)	28 (90%)	1 & 3	2.14	.020*	*0.39 (Small)*

* p-value ≤ 0.05; ** p-value ≤ 0.01

Inferential tests were completed to test for any significance between the sustainability reporting tools and technologies (Table 5-23). These tools and technologies were grouped into significant groupings (Rank 1 to 2) in terms of importance. The technology 1 "*Excel*" was compared to technologies 2 "*Internal information systems*" and 3 "*Web-based reporting tools*" and "*Web-based reporting tools*" was compared to technology 4"*Sustainability reporting system*". The only technology with a mean rating significantly less than that of technology 1 is technology 3"*Web-based reporting tools*" in rank grouping 2

Table 5-23 also lists the tools and technologies used in organisations for EA. The tools and technologies with the highest rating was "*Excel*" (μ = 3.81) and "*Internal information systems*" (μ = 3.55) are rated highest and second highest respectively and "*Sustainability reporting system (web-based)*" (μ = 2.84) is rated lowest.

Table 5-23: Sustainability Reporting Tools and Technologies (n = 31)

Sustainability Reporting Tools and Technologies	Rank	Mean	SD	Inferential test			
				Sustainability Reporting Tools and Technologies Compared	*t*-value	p-value	Cohen's *d*
1. Excel	1	3.81	0.91	-	-	-	-
2. Internal information systems	1	3.55	1.23	1 & 2	0.97	.170	0.17
3. Web-based reporting tools	2	2.94	1.50	1 & 3	2.47	.010**	*0.44 (Small)*
4. Sustainability reporting system (web-based)	2	2.84	1.51	3 & 4	0.62	.270	-

* p-value ≤ 0.05; ** p-value ≤ 0.01

The majority of the participants selected that their organisations always use "*Excel*" with the highest frequency count (n = 21) in the positive range (Figure 5-16). This confirms the study by Ernst & Young and GreenBiz Group (2012) showing that many organisations still use spreadsheets for reporting activities. The least used tool and technology amongst the participating organisations is "*Sustainability reporting system (web-based)*" with the lowest frequency count (n = 12) in the positive range and a high frequency count (n = 12) in the negative range.

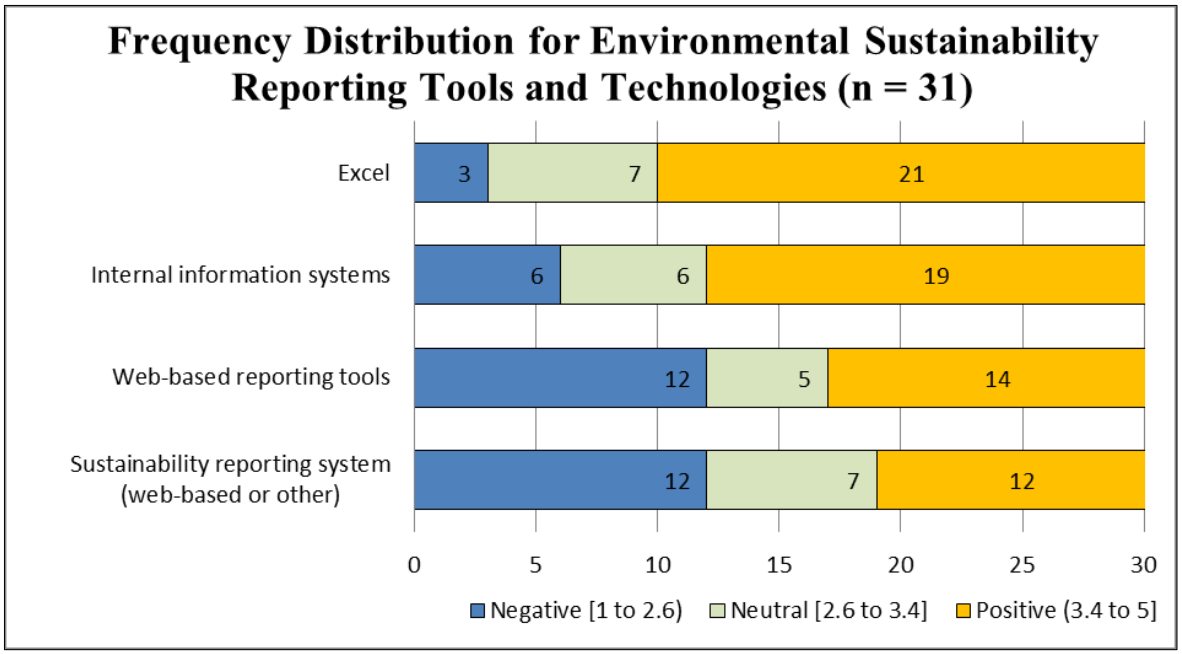


Figure 5-16: Tools and Technologies for Environmental Sustainability Reporting

The participants listed the types of tools and technologies used in their organisations for environmental sustainability reporting not supported in the provided list (Table 5-24). The majority of the participants (n = 11) listed that their organisation uses internal tools and technologies. SAP (n = 5) was also listed several times amongst the participants as an information system used for environmental sustainability reporting activities. The reset of the tools and technologies that were listed had a frequency count of one (n = 1).

Table 5-24: Types of Tools and Technologies for Environmental Sustainability Reporting

Sustainability reporting system	**Web-based reporting tools for Sustainability reporting**	**Internal information systems for Sustainability reporting**
Enablon - Sustainability Module (n = 1)	Enablon - H & S and Sustainability Module (n = 1)	Cognos Reporting (n = 1)
Excelsius reporting tool (n = 1)	GreatSoft (n = 1)	Environment (n = 1)
GreatSoft (n = 1)	Intranet (n = 1)	Environmental control systems (n = 1)
Internal (n = 4)	Internal (n = 3)	Excel (n = 1)
Intranet (n = 1)	Organisation Portal (n = 1)	GreatSoft (n = 1)
SAP (n = 1)	Structured Query Language (SQL) (n = 1)	Internal (n = 4)
		SAP (n = 4)
		SharePoint (n = 1)

Table 5-25 shows the environmental (EN) indicators ranked on their mean ratings. Based on the outcome of the reported inferential tests the EN indicators are grouped in two significance groups (Rank 1 to 2):

- Group 1: Indicators 1 to 2 with no significant difference between indicators 1 "*Direct energy consumption by primary energy source*" and 2 "*Initiatives to reduce greenhouse gas emissions and reductions achieved*" in this group; and
- Group 2: Indicator 3 "*Total direct and indirect greenhouse gas emissions by weight*" was the only EN indicator with a mean rating significantly less than that of EA indicator 1. Indicators 4 to 6 had no significant difference in this group.

The ratings for the EN indicators are presented according to the mean values and the three highest rated EN indicators are shown in bold-typeface (Table 5-25). The highest rated two EN indicators were EN3 – Direct energy consumption by primary energy source (μ = 3.58) followed by EN18 – Initiatives to reduce greenhouse gas emissions and reductions achieved (μ = 3.35). The bottom two rated EN indicators were EN10 – Percentage and total volume of water recycled and reused (μ = 2.90) and EN9 – Water sources significantly affected by withdrawal of water.

Table 5-25: Environmental (EN) Indicators (n = 31)

EN Indicators	Rank	Mean	SD	Inferential test			
				EN Indicators Compared	*t*-value	p-value	Cohen's *d*
1. EN3- Direct energy consumption by primary energy source.	1	3.58	1.36	-	-	-	-
2. EN18 - Initiatives to reduce greenhouse gas emissions and reductions achieved.	1	3.35	1.38	1 & 2	1.37	.091	0.25
3. EN16 - Total direct and indirect greenhouse gas emissions by weight.	2	3.10	1.37	1 & 3	2.34	.013*	*0.42 (Small)*
4. EN4 - Indirect energy consumption by primary source.	2	3.06	1.24	3 & 4	0.14	.447	-
5. EN8 - Total water withdrawal by source.	2	3.06	1.59	3 & 5	0.18	.430	-
6. EN17 - Other relevant indirect greenhouse gas emissions by weight.	2	2.90	1.30	3 & 6	1.53	.068	0.28
7. EN10 - Percentage and total volume of water recycled and reused.	2	2.90	1.62	3 & 7	0.88	.193	0.16
8. EN9 - Water sources significantly affected by withdrawal of water.	2	2.77	1.50	3 & 8	1.62	.058	0.29

* p-value ≤ 0.05; ** p-value ≤ 0.01

The three EN indicators with the highest frequency counts which were rated most important amongst the participants were: EN3 – Direct energy consumption (n = 20), EN18 – Initiative to reduce greenhouse gas emissions and reductions achieved (n =17) and EN8 - Total water withdrawal by source (n = 15) all in the positive range (Figure 5-17). The two EN indicators which were rated the least important amongst the participants were: EN10 - Percentage and total volume of water recycled and reused (n = 16) and EN9 - Water sources significantly affected by withdrawal of water (n = 16) both with the highest frequency counts in the negative range. This confirms the study of Rea (2012).

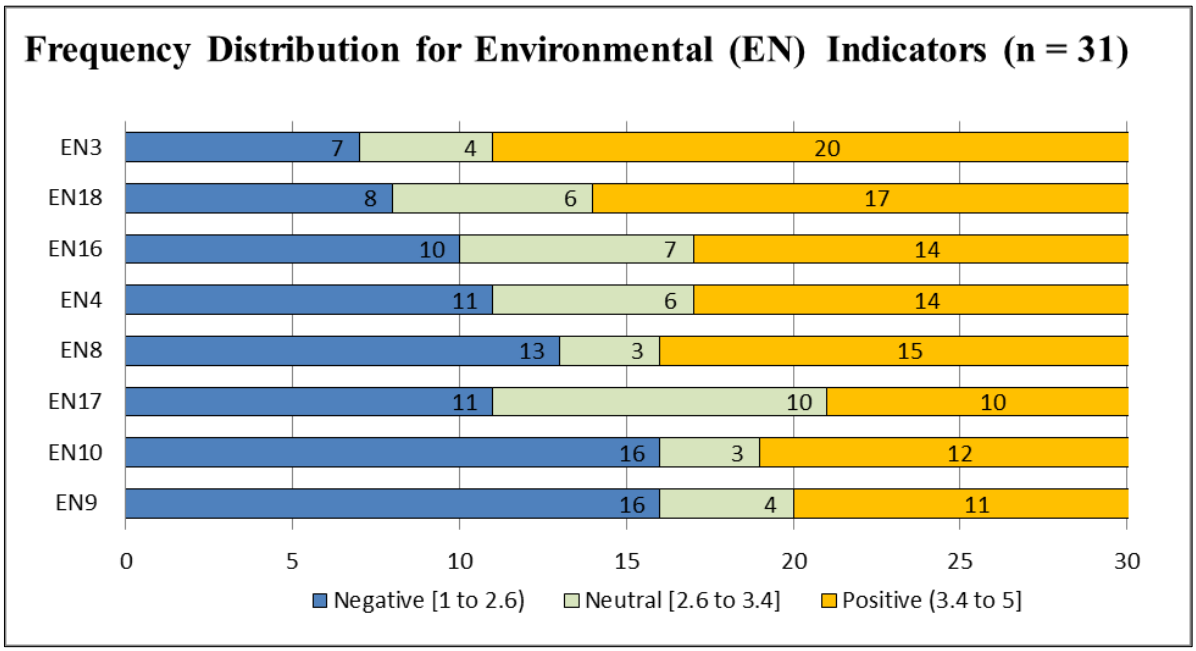


Figure 5-17: Environmental (EN) Indicators

5.5.2 Environmental Information Management Questionnaire Qualitative Results

The EIM questionnaire consisted of open-ended questions where the participants had the opportunity to express their opinions. The participants had to indicate whether they had experienced any benefits and challenges with environmental sustainability reporting. These comments were analysed using the Atlas.Ti application and coded into predefined categories. The categories are the benefits (Table 5-26) which are identified in literature (Section 2.3). The benefits identified were used as the predefined categories whereby the codes were mapped to these categories. A list of 14 codes was identified for the environmental sustainability reporting benefits. The frequency (f) count for each code, which was found amongst the participants (n = 30) responses is listed and those frequency counts which were ranked highest are represented in bold-typeface (Table 5-26).

The benefits with the highest frequency counts (bold-typeface in Table 5-26) were "c*ompliance*" (f = 6), "*positive reputation*" (f = 4) and "*transparency*" (f = 4) listed in Table 5-26. This confirms the study by Ernst & Young LLP and Boston College (2013) which show that organisations can gain a positive reputation through environmental sustainability reporting. These reports also help organisations to achieve compliance with legal and other requirements. The responses of the participants were mapped to the appropriate benefits codes which illustrate the types of benefits listed by the participants to give a better understanding of the meaning of the codes.

Table 5-26: Environmental Sustainability Benefits Classified by Categories

Categories	Codes	Examples of the responses
Compliance with legal and other requirements	**compliance (f = 6)**	*conformance with group requirements; compliance to audit findings*
Reputation enhancement	**positive reputation (f = 4)**	*higher image amongst our customers, that we do care about the environment*
Greater transparency	**transparency (f = 4)**	*perceived as a transparent company, due to the environmental reporting; through greater transparency*
Strengthens stakeholders relationship	better stakeholder relationship (f = 2)	*it strengthens the relationships with our stakeholders by involving them our reporting process*
Better brand alignment	brand alignment (f = 2)	*raises the profile of our brand*
Competitiveness	competitiveness (f = 2)	*competitive position: lower carbon footprint proven electricity savings*
Demonstrating good corporate citizenship	corporate citizenship (f = 2)	*demonstrating good corporate citizenship. staff and stakeholders like to be associated with company's doing the right things*
	improved productivity (f = 1)	*improved productivity*
Allow for targets and KPIs to reduce risk and identify opportunities	establishing targets (f = 1)	*establishing targets for minimizing targets and instituting programs for enhancement of environmental management*
	opportunities (f = 1)	*creates recycling opportunities*
Improved efficiency and productivity	improved efficiency (f = 1)	*reduced costs improved efficiency*
Market access	market access (f = 2)	*we potentially see a benefit in an increase in the number of customers/stakeholders who share the same values as us*
Strategic alignment	strategic alignment (f = 3)	*accurate reflection of business environment*
Focus on and raises awareness of sustainable practices	sustainability awareness (f = 2)	*engenders a focus on sustainability issues in the organisation*

The environmental sustainability challenges listed by the participants were coded and mapped to the predefined categories (Table 5-27). The categories are the challenges which were identified in literature (Section 2.4). The codes were derived from the list of challenges identified by the participants. A list of 14 codes was derived from the responses and those frequency counts which were ranked highest are represented in bold-typeface. The challenges with the highest frequency counts were "*accuracy and completeness of data*" (f = 5), "*stakeholder buy-in*" (f = 4) and "*standardisation of reports*" (f = 4).

Studies (Ernst and Young LLP and Boston College, 2013; KPMG, 2008; Solsbach *et al.*, 2011) confirming the accuracy and completeness of data show that this is a primary challenge for organisations managing environmental sustainability information. KPMG (2008) and UNEP *et al.* (2010) confirm the standardisation challenge, whereby organisations have to produce a standardised environmental sustainability report. Table 5-28 also shows the challenges identified by the participants are mapped to the appropriate categories and codes. These examples help with understanding the context of the codes.

Table 5-27: Environmental Sustainability Challenges Classified

Categories	Codes	Examples of the responses
Quality of data	**accuracy and completeness of data (f=5)**	*effectively collating all the information; obtaining reliable and accurate data from external sources*
Buy-in to disclose data	**stakeholder buy-in (f = 4)**	*board commitment, employee commitment; getting internal buy-in can be difficult*
Compliance and Standarisation	**standardisation of reports (f = 4)**	*IT systems; standardised reporting formats; absence of a generally accepted framework*
Data collection and Access to information	access to information (f=1)	*access to information*
	data collection (f=2)	*…difficult to collect all the required information - leading to potential under reporting*
	information capturing (f=1)	*capturing the data and information for reporting and auditing purposes*
	information sharing (f=1)	*…very positive learning's with regards to water and energy which might not be shared that well*
	record keeping (f=1)	*insufficient and distributed record keeping presented a challenge to account for and measure sustainability efforts*
Communication between departments	communication between parties (f = 1)	*external parties helping with sustainability reporting attempted to force their view*
Transparency and disclosure to stakeholder	disclosure of information (f = 1)	*getting the reporting tone correct as well as effort needed for environmental reporting*
	reaching target audience (f = 1)	*not always easy reaching the target audience*
Moving from costs to revenue	high costs (f = 2)	*it is costly to collect all the relevant information for detailed management and reporting; cost of environmental efficiency technologies*
Skills Shortage	no skills (f = 2)	*no skills*
Short-term versus long-term	not a priority (f = 2)	*not seen as required at present (although it should be)*

5.6 Interview Analysis

A face-to-face interview with an EA expert of one of South Africa's leading insurance companies resulted in many aspects of the research findings being confirmed and highlighted. The purpose of the interview was to triangulate results and to confirm some unclear responses from the EA and EIM questionnaires to explain the position as an organisation as to whether its EA design includes environmental information. The following discussions are based on this single interview with the EA expert (the interviewee).

Key themes were identified during the interview with the interviewee. The following themes included benefits, challenges and the interviewee's perspective about the EA and EIM topics were:

- Alignment of environmental strategy with the organisation's strategy;
- Transparency can be achieved with EA in terms of the organisation's processes; and
- Challenges were: reactive operations versus proactive operation.

The use and importance of the four common components namely, Business Architecture, Information Architecture, Application Architecture and Technology Architecture was confirmed. The interviewee said

> "*...we have an information model as we indicated and is based on the information services… and then we have the business processes that models on top of them so literally if you look at the diagram you can actually plot them into those four main common components*". The interviewee further indicated that: "*we have our application model as I have indicated we introduced the process layer and we line that to the Component Business Model; is a mechanism whereby we align the strategy of the business to the underlining services*".

The interviewee was asked to explain their perception on how their EA design includes environmental information. The interviewee responded:

> "*... my view is it would become another element in terms of the way you would structure or you would align your underlying aspect whereas from a financial perspective you have that significantly this is just another dimension that we bring in here…".* The interviewee went on to say that *"Strategically it needs to become something that we can influence and that's what I would do initially until it becomes legislated*".

This supports the study by GRI (2013b) showing that a limited number of South African organisations from a variety of sectors are providing an integrated sustainability report and studies (Ernst and Young and GreenBiz Group, 2012; KPMG, 2008; Magoulas *et al.*, 2012; Speshock, 2010) citing the importance of including EIM and sustainability concerns in an organisation's strategy. The interviewee confirmed that their EA design is flexible and can accommodate environmental sustainability strategy and information management.

The importance or transparency (Table 5-26) in sustainability reporting and of having a transparent sustainability strategy and to include this strategy in the EA was also confirmed by the interviewee who stated that the:

> "*...whole thing around consumer versus provider that fundamentally creates that visibility perspective in terms of reporting ... unfortunately many organisations are not geared that way so they will take the technical strategy that will saying now I need to report on environment, or I need to report on say legislative, I need to report on financial they will build whole areas around that but that's a reactive strategy it's not built core into your underlying architecture so you as an organisation are doing this in a reactive scenario ... we don't know if we use that context efficiently that stands to a lot of things that stands to whether the Chief Executive Officer (CEO) is going to run the business correctly whether the CIO is making it part of their strategy. Ultimately from an architecture perspective what I have tried to do is transparency. The problem is if you don't have visibility you will never be in a position to change that, you will have an issue occurring and then you will effectively rally the troops to address the issue and do a report that is not what I want. My architecture style is proactive I like to understand and be agile*".

The interviewee highlighted that to have visibility for EIM and reporting using EA is important to handle change and to make informed decisions. The interviewee therefore confirmed one of the EA benefits coded as "visibility" under the representation category (Table 5-14). The interviewee said:

> "*I think the biggest benefit ... is literally as indicated, business visibility without that you get large corporates that operate at 40% of their capacity why because they don't have visibility"*.

The interviewee addressed challenges with EA adoption. The interviewee said:

> "*IT is not being seen as I mean for a very long time it's been an operational concern and the reality is it's no longer that, it has to be incorporated with the strategic vision. So the challenge is… EA specifically is about compromise, there is no other way to do it…trying to bridge these two gaps*".

The gaps which are being referred to here relate to the gaps of business and IT. The importance of business-IT alignment and related challenges are therefore confirmed which supports several studies (Pereira, 2005; Ritter, 2007; Schekkerman, 2011b; Speshock, 2010; Wang *et al.*, 2008) showing this challenge (Section 2.8).

The interviewee also identified the challenge of EA adoption as follows: "*I think the other big challenge is the rate of adoption of technology, really getting people up and this is the problem we have in industry*". This confirms the study by Lucke *et al* (2010) who reports on representation challenges for EA and technology (Table 3-3). Another challenge identified by the interviewee was resistance to change

> "*… many enterprises sit with a situation where because of their big investment in IT, It actually controls them. Purely because 1) the people aren't able to change and 2) they don't want to change so that's the other big challenge we find. It's strange that you would hear that from an IT person but I have encountered in my career many IT people are very change-resistant, once they achieve a certain level they are very resistant to change and yet we preach change and the reality is we don't practice it*".

This supports the study by Lucke *et al* (2010) who classifies the complexity challenge of rapidly changing conditions (Table 3-3). The interviewee then explained their status regarding the use of environmental sustainability tools and technologies, saying:

> "*… from a sustainability perspective we want the capability to actually become more proactive. Reactive capability is mainly in the form of Business Intelligence so we harvest a lot of stuff from our system and then report according, so it's not ideal*.

The interviewee also explained whether their environmental sustainability reporting system is isolated, saying: "*No, it's not isolated currently and like what you said where we are moving to becomes another report that is drawn from our system that is another dimension so currently its mainly collected through various other systems and reported accordingly*". This discussion confirms the proposed features and benefits of an integrated Environmental Management Information System (EMIS) identified in Chapter 3 (Section 3.8).

The interviewee said that their main environmental sustainability challenge is:

> "*... from a technological perspective how we bring other pieces of technology that deviate that footprint… so a large portion of that in terms of sustainability is also in … we are trying to cut the silos because that's one of the ways you do not get sustainability because we have complications*".

This confirms the challenges of "*Data collection and access to information*" and "*Transparency and disclosure to stakeholders*" (Table 2-2). Therefore the main theme that was highlighted from the interview was that EAs can be used to support the environmental sustainability and EIM and reporting operations in organisations.

5.7 Conclusions

Research question five (RQ5) for this chapter was answered by achieving the fifth research objective (RO5) which was *To investigate Enterprise Architecture and environmental sustainability reporting practices in South African organisations*. An industry survey of 31 South African organisations was undertaken in order to empirically validate the theory of EIM (Chapter 2) and EA (Chapter 3). The status of South African organisations was identified for their EA and environmental sustainability reporting practices. All acceptable Cronbach's alphas were achieved in both the EA and EIM questionnaires confirming the internal reliability of the questions. The industry survey was based on the EA for EIM Toolkit (Version 1) which was introduced in Chapter 3 (Section 3.10). The Version 1 of the toolkit was then updated to Version 2 (Figure 5-18). The highest rated qualitative results (Section 5.4.2 and 5.5.2) confirmed the quantitative results (Section 5.4.1 and 5.5.1) and therefore triangulation of the data collected was achieved and no added elements from the qualitative results are reflected in the EA for EIM Toolkit (Version 2).

The size of the participating organisations was primarily medium to large with over 500 employees and the majority were JSE listed organisations from a variety of industries. The results show that the 61% of the participating organisations have an EA programme in place and that they use all four main components of an EA namely, business architecture, information architecture, application architecture and technology architecture. The most frequently adopted internationally accepted EA framework by the organisations is TOGAF (54%).

The EA for EIM Toolkit (Version 2) was designed based on the EA and EIM questionnaires results (Figure 5-18). The three highest rated results for the different aspects in both the questionnaires were included in the updated toolkit. This updated toolkit is proposed as a solution for organisations to align their business-IT and environmental sustainability strategies across the entire organisation. The alignment is proposed on the three process levels within an organisation namely, strategic level, operational level and the technological level.

The alignment should also be extended onto the four main EA components namely business architecture, information architecture, application architecture and technology architecture. The EA for EIM Toolkit (Version 2) will be included in the case study for further validation of this proposed solution.

Economic reporting is the primary type of reporting which the organisations regard as part of their processes however environmental reporting does not seem to be a priority amongst the organisation's processes. This supports the study by Rea (2012). Organisations (52%) use the internationally accepted standard ISO 14001. Studies show that the ISO 14001 standard is mostly adopted by South African organisations and in Africa as a whole (ISO, 2012). Spreadsheets seem to be the most popular tool used for environmental sustainability reporting amongst the participating organisations (n = 21), but internal information systems are also mostly used for this purpose by the organisations (n = 19). EN3 - "*Direct energy consumption by primary energy source*" seems to be a critical concern for the majority of the organisations as 64% of the organisations selected this GRI environmental indicator to be reported. Challenges were identified regarding environmental sustainability reporting and the organisations listed "*standardisation of reports*" and "*accuracy and completeness of data*" as the main challenges for this type of reporting. Many benefits were achieved by the organisations that use environmental sustainability reporting namely "*compliance*" and "*positive reputation*".

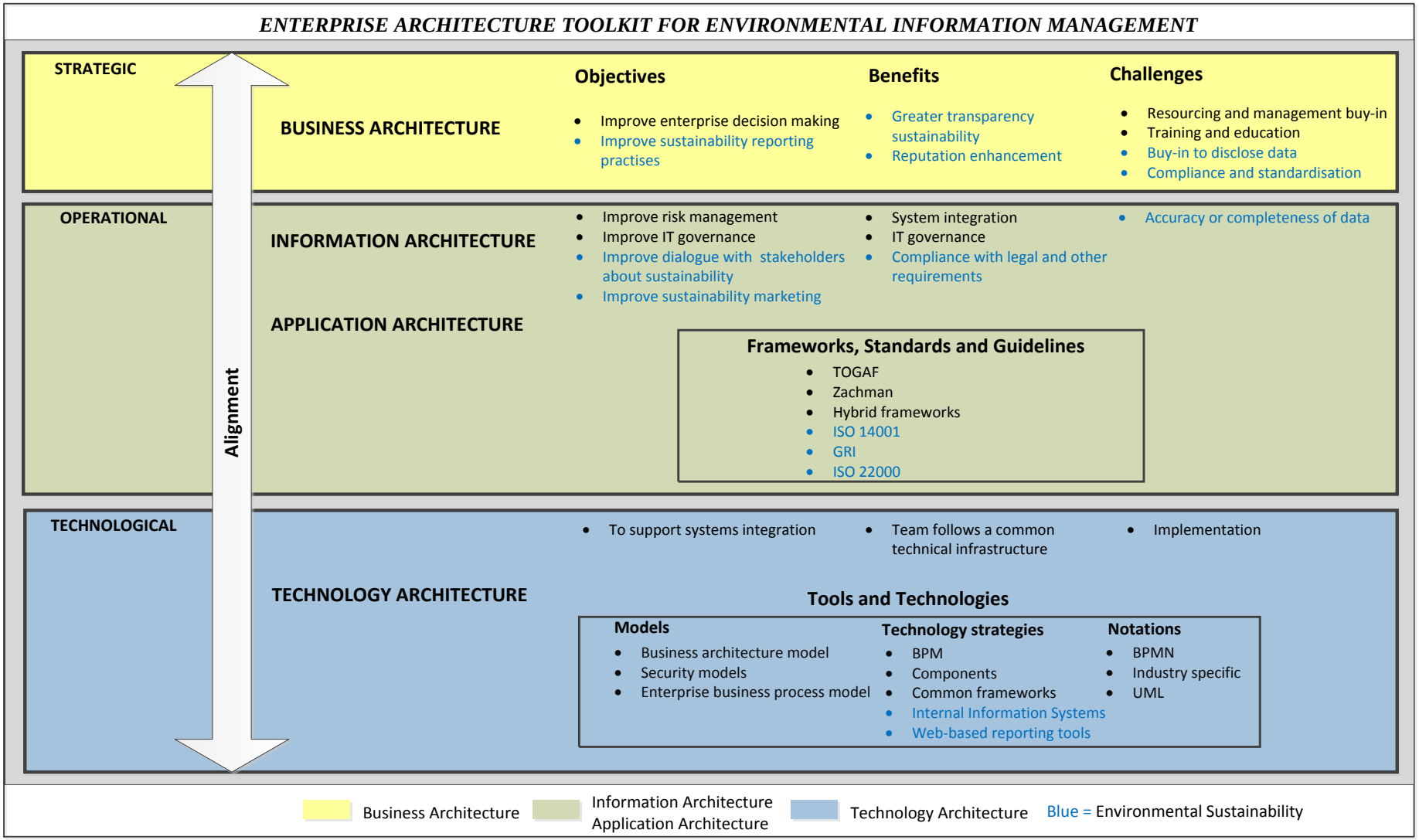


Figure 5-18: EA for EIM Toolkit (Version 2)

The highest rated three EA objectives according to the mean values were "*Improve risk management*", "*Improve IT Governance*", and "*Support system integration*". The highest rated three benefits which were achieved by the organisations using EA are "*System integration*", "*IT governance*" and "*Team follows a common technical infrastructure*". The participants also listed additional EA benefits and the two benefits with the highest frequencies were "*commonality*", "*standardisation*" these benefits were already identified in terms of the quantitative results (Table 5-14) and therefore triangulation was achieved. The challenges which were identified in literature and confirmed by questionnaire results experienced with EA were "*resource and management buy-in*", "*training and education*" and "*implementation*". The technologies that are used frequently by the organisations are "*BPM*", "*SOA*" and "*Common Frameworks*". The organisations use models to help them to structure the EA according to their needs such as "*Business architecture models*", "*Security models*" and "*Enterprise business process models*".

More than half of the participants (52%) also said that their organisations do consider environmental strategy and EIM when they design their EA. The organisations were asked whether they practice sustainability reporting and 61% said that they practice sustainability reporting internally as well as provide a sustainability report to external stakeholders. The majority of the participants also agreed that the target audience for their sustainability reports are customers, employees and government. The environmental sustainability objectives "*Improve sustainability practices*", "*Improve dialogue with stakeholders about sustainability*" and *"Initiate programmes to eliminate hazardous substances in materials and parts purchased*" were rated highest amongst the participants.

The next chapter will describe the case study process and the analysis of case study results. The organisations that will be selected for the case study are based on the results from the questionnaires. The top five organisations will be selected to partake in the case study based on how they scored in both questionnaires. This will also allow for guidelines to be proposed from theory and from the organisations that have evidence of best-practice processes. These organisations will have to validate the toolkit and their proposals for the toolkit resulting from the case study will be reflected in the final EA for EIM Toolkit (Version 3).

Chapter 6 Case Study Process and Findings

6.1 Introduction

In the previous chapter the results from the survey study were analysed and presented and an updated Enterprise Architecture (EA) for Environmental Information Management (EIM) Toolkit (Version 2) was proposed (Figure 5-18). The findings from the survey study were used to indicate the selection of those organisations that follow best-practice for EA and environmental sustainability practices that were chosen to take part in the case study of this research. The Toolkit (Version 2) includes the main findings from the theory, confirmed by the survey study which was used in the toolkit as proposed guidelines for organisations to follow in order to achieve alignment between business-Information Technology (IT) and environmental sustainability strategies. This Toolkit (Version 2) will be included in the case study for further validation of the proposed guidelines.

This chapter will address the sixth research question (RQ6) namely: "*How are successful South African organisations using Enterprise Architecture to support environmental sustainability reporting and Environmental Information Management*?". This research question will be answered through the case study strategy. The case study will include interviews from a selected number of the organisations surveyed (Chapter 5). The participants were selected for the case study based on how they scored in the EA and EIM questionnaires (Section 6.2). Another factor which affected the selection of the participants was willingness to participate in the study. The aim was to select at least the top five participating organisations based on their overall score for both the questionnaires, and one or two additional organisations which were willing to participate and scored at least neutral to positive in both questionnaires. The research process for the case study is illustrated (Section 6.3). The results of the case study will be analysed and presented (Section 6.4). A conclusion will be made based on an analysis of the case study and an updated EA for EIM Toolkit (Version 3) will be presented to reflect any additional guidelines derived from the case study (Section 6.5). The structure of this chapter is also presented (Figure 6-1).

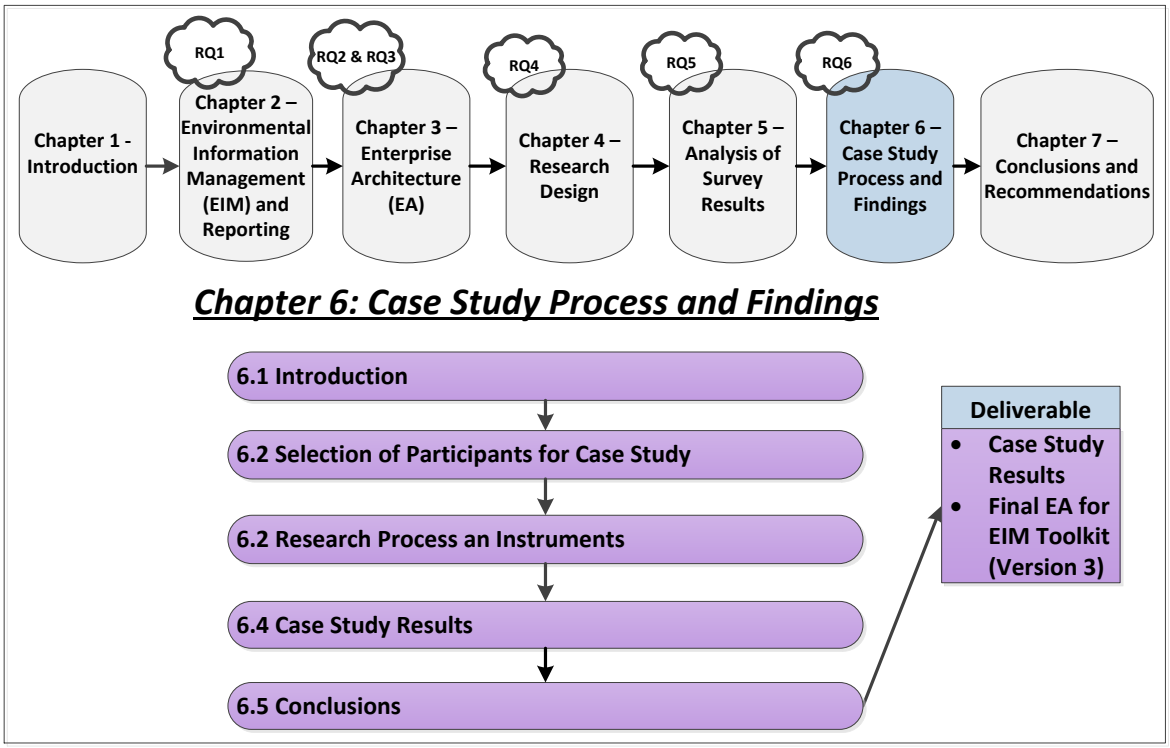


Figure 6-1: Chapter 6 Structure

6.2 Selection of Participants for the Case Study

Organisations listed on the Johannesburg Stock Exchange (JSE) have become a reference to many other organisations for producing environmental sustainability reports (KPMG, 2008). Research shows that JSE-listed organisations have experience in producing environmental sustainability reports. Therefore the fact that the top five organisations were JSE-listed, was also taken into consideration when selecting the case study organisations. The other main factor for selecting the participants was based on their responses to the EA (Appendix I) and EIM (Appendix J) questionnaires. The scoring and selection process involved converting all the scales used in the questionnaires to standard scoring values (Table 6-1) in order to rate and rank the organisations. The scoring values were created with the assistance of the statistician consultant (Venter, 2013).

For the No/Yes questions a zero was allocated for a 'No' and a one for a 'Yes' response (Table 6-1). The 0-scale value was converted to a 0-score and is described as *Very-Negative (V.Neg)*. A 10-score was given for a scale value of 1 which is described as *Very-Positive (V.Pos)*. The scale values for all the 5-point Likert scale questions were converted to the following scoring values: [0,2) if the scale value was 1 and is described as *Very-Negative (V.Neg)*, [2,4) if the scale value was 2 and is described as *Negative*, [4,6] if the scale value was 3 and is described as *Neutral*, (6,8] if the scale value was 4 and is described as *Positive* and (8,10] if the scale value was 5 and is described as *Very-Positive (V.Pos)*.

Table 6-1: Scoring Values and Descriptions[2]

Question Type	Scale Values from Questionnaires	Scoring Values	Range Description
Yes/No	0 (No)	0	Very-Negative (V.Neg)
	1 (Yes)	10	Very-Positive (V.Pos)
5-point Likert scale values	1	[0,2)	Very-Negative (V.Neg)
	2	[2,4)	Negative
	3	[4,6]	Neutral
	4	(6,8]	Positive
	5	(8,10]	Very-Positive (V.Pos)

The scale values were converted to the scoring values for each section of each response for both the EA and EIM questionnaires. The scores for each participant's responses were then averaged to get an overall score for both the EA and EIM responses. These scores were then averaged for each participant's responses for both EA and EIM questionnaires combined to get an overall ranking on how each participant scored for both questionnaires per organisation (Table 6-3). A detailed table and other relevant calculations of the derived scores are also available (Appendix K). The organisations were ranked in descending order of Very-Positive to Very-Negative first based on the EA and EIM questionnaires, then in terms of both questionnaires combined. The industries of each organisation were grouped into the three main industry groups namely, 1) Financial, 2) Manufacturing and 3) Service. The 31 organisations that completed the questionnaires were represented by a number preceded with the letter C for company for the sake of anonymity.

[2] [Greater than or equal to;
) Less than.

Figure 6-2 illustrates the overall ranking categories (RC) for each questionnaire RC.EA and RC.EIM as well as the ranking for both questionnaires combined RC.EA and EIM. Sixty two percent of the participants were ranked *Positive and Very-Positive combined* for their EA responses and 3% were ranked *Very-Negative*. None of the participants had a *Very-Negative* ranking for the EIM questionnaire and 58% were ranked *Positive and Very-Positive combined*. Overall for both questionnaires the majority of the participants were ranked *Positive* (45%) and none for *Very-Negative*.

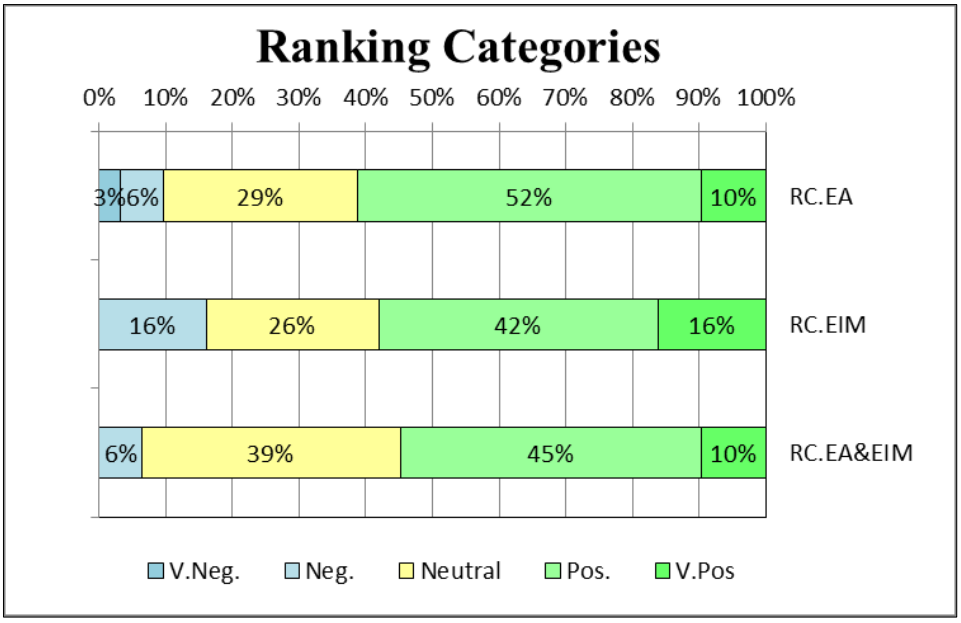


Figure 6-2: Ranking Categories

The mean values per questionnaire section are ranked and illustrated (Table 6-2). Each of the sections that was included in the ranking process for both the EA and EIM questionnaires are shown under questionnaire section. The EA questionnaire (Appendix I) section "Objectives" has the highest overall mean (μ = 7.24) with 80% of the responses in the *Positive* and *Very Positive* range combined for this section and the section "Modelling notations" has the lowest overall mean (μ = 5.63) of which 20% of the responses were in the *Negative* and *Very Negative* range combined in this section. The section "Status of sustainability reporting" in the EIM questionnaire (Appendix J) has the highest overall mean (μ = 7.90) of which 61% of the responses were in the *Very Positive* range and the section "Standards and methods" with the lowest mean (μ = 4.97) with 36% of the responses were in the *Negative* and *Very Negative* range combined in this section.

The averages of the overall mean values per questionnaire for all sections combined are also given (Table 6-2). The overall mean value for the EA questionnaire (μ = 6.40) of which 62% is *Positive* responses and for the EIM questionnaire (μ = 6.28) of which 58% is *Positive* responses. The average of the overall mean values for both EA and EIM questionnaires combined were calculated (μ = 6.34) with 55% *Positive* responses, 6% *Negative* responses and 39% of the responses were *Neutral*.

Table 6-2: Overall EA and EIM Distribution of Mean Values per Questionnaire Section

Questionnaire	Mean	Questionnaire Section	Ranges				
			V.Neg	Negative	Neutral	Positive	V.Pos
EA Sections	7.24	Objectives	3%	10%	7%	35%	45%
	7.03	Components	0%	9%	26%	52%	13%
	6.55	Models	3%	7%	32%	32%	26%
	6.29	Technology strategies	3%	3%	39%	39%	16%
	5.65	EA status and number of years for EA programme	4%	13%	35%	35%	13%
	5.63	Modelling notations	10%	10%	42%	22%	16%
	6.40	All EA sections combined	3%	6%	29%	52%	10%
EIM Sections	7.90	Status of sustainability reporting	3%	0%	36%	0%	61%
	7.74	Stakeholder concerns	0%	0%	26%	19%	55%
	6.89	Organisation processes	0%	6%	23%	52%	19%
	6.18	Objectives	3%	26%	10%	35%	26%
	5.71	Tools and technologies	6%	19%	16%	48%	10%
	5.65	Target audience	26%	13%	3%	13%	45%
	5.23	Environmental (EN) Indicators	16%	13%	25%	23%	23%
	4.97	Standards and methods	26%	10%	22%	29%	13%
	6.28	All EIM sections combined	0%	16%	26%	42%	16%
EA & EIM Questionnaire Sections Combined	6.40	EA all sections combined	3%	6%	29%	52%	10%
	6.28	EIM all sections combined	0%	16%	26%	42%	16%
	6.34	All EA&EIM sections combined	0%	6%	39%	45%	10%

Seven organisations were selected for the case study analysis and interviews (Table 6-3). These were the top five organisations that had an overall *Very-Positive* and *Positive* ranking for both questionnaires combined, and two other organisations (C19, C04) with an overall ranking of *Positive* and *Neutral* who were also selected based on their willingness to participate in the case study.

Table 6-3: Ranking Categories of Case Study Participants

		Ranking Category-EA Questionnaire			**Ranking Category-EIM Questionnaire**			**Ranking Category-EA and EIM Questionnaires Combined**		
Organisation Number	**Type of Industry**	**Score**	**Rank**	**Cat.**	**Score**	**Rank**	**Cat.**	**Score**	**Rank**	**Cat.**
C07	2	9.34	1	V.Pos	8.97	1	V.Pos	9.15	1	V.Pos
C28	3	8.73	2	V.Pos	8.21	5	V.Pos	8.47	2	V.Pos
C20	3	7.63	9	Positive	8.78	3	V.Pos	8.20	3	V.Pos
C14	3	8.16	3	V.Pos	7.82	8	Positive	7.99	4	Positive
C13	3	7.80	4	Positive	7.91	6	Positive	7.85	5	Positive
C19	1	5.96	20	Neutral	7.33	13	Positive	6.65	15	Positive
C04	3	7.47	11	Positive	3.24	29	Negative	5.36	26	Neutral

All seven of the participants were male and six of the organisations are listed on the JSE index (Table 6-4). The two organisations that were selected based on their willingness to participate were ranked 15th and 26th overall based on their EA and EIM questionnaire results.

Table 6-4: Case Study Participants Profile (n = 7)

Organisation	**Overall Rank**	**Industry Type**	**JSE Listed**	**Job title**
C07	1	Consumer Goods	Yes	Engineering Consultant
C28	2	Insurance	Yes	Applications Architect/Developer
C20	3	Energy & Utilities	Yes	Divisional Executive – Sustainability
C14	4	Logistics and Transportation	Yes	Business Architect
C13	5	Insurance	Yes	Enterprise Architect
C19	15	Assurance	Yes	Information Architect
C04	26	Finance	No	IT Manager

6.3 Research Process and Instruments

An expert review was proposed whereby an EA consultant who was one of the participants from an EA consulting organisation was asked to validate the EA for EIM Toolkit (Version 2). The EA consultant is responsible for creating customised EAs for different types of organisations based on their needs and requirements. The EA consultant offered to provide guidance from an expert perspective for the proposed EA for EIM Toolkit (Version 2). A pilot version of the case study interview questions, the proposed guidelines and the EA for EIM Toolkit (Version 2) was sent to the EA consultant for validation to determine any potential problems or misunderstandings.

All the interview questions and what was proposed in the toolkit guidelines were verified by the EA consultant and no changes were recommended. However, the EA consultant advised that all elements within the toolkit should be presented in an integrated manner. For example the initial toolkit contained two separate lists of EA and environmental sustainability objectives and benefits and the consultant advised combining these into one list. This was updated in the EA for EIM Toolkit which was included in the case study. This change was reflected where one list was shown for the EA and environmental sustainability elements and the list for environmental elements was presented in the blue (Figure 5-18).

The participants were contacted via telephone and asked for their permission to include them in the case study. Emails which contained a cover letter (Appendix G) which briefly explained the purpose of the case study were then sent to the participants. The emails also contained a document with the EA for EIM Toolkit and the proposed guidelines. The participants were requested to read through the documentation before the interviews in order to prepare for the interview and to be able to answer the questions regarding the toolkit and the guidelines. This also allowed for the interviews to be kept short with a maximum of 30-minutes per interview.

The EA for EIM Toolkit (Version 2) in Chapter 5 (Figure 5-18) is proposed in order to assist organisations with the use of EA to support EIM and reporting. Guidelines for all three levels of an organisation are also provided. The main elements of the toolkit are:

- To assist with setting strategic objectives for Environmental Sustainability (Section 2.2);
- To use EA to align IT and business and therefore IT and environmental strategy (Section 2.8);
- To provide guidance regarding identifying potential challenges and risks of EA and environmental sustainability in order to improve the chances of success (Sections 2.4 and 3.5);
- To identify the most popular and internationally accepted EA frameworks and environmental sustainability standards (Sections 2.5 and 3.2); and
- To propose tools and technologies for EA and environmental sustainability that are aligned with each other and with the business strategy (Sections 2.6 and 3.7).

The guidelines for the toolkit are mapped on the three process levels within organisations namely: the strategic level, the operational level and the technology level (Table 6-5). The twenty guidelines are proposed based on each process level of organisations.

Two sets of questions were asked during the interviews with participants. The first set was based on confirming the results from the survey study for that participant's organisation. The second set was based on the proposed guidelines (Table 6-5) and the EA for EIM Toolkit (Version 2) in Chapter 5 (Figure 5-18) in order to validate the guidelines and the toolkit. Table 6-6 illustrates the two sets of interview questions and the responses from the participant for each interview.

Table 6-5: EA for EIM Toolkit Best Practice Guidelines

Process level	Guidelines
Strategic level	1. Use an internationally accepted EA framework. 2. The EA strategy and objectives must consider environmental sustainability strategic objectives. 3. When considering the potential benefits of EA an organisation needs to consider the benefits to all stakeholders of environmental initiatives and environmental reporting. 4. Identify potential challenges and risks of environmental reporting in EA. these can be used to reduce risks. 5. Use EA to align IT and business and therefore IT and environmental strategy. 6. At the strategic level the Business Architecture level of the EA must be considered.
Operational level	7. Align the Information Architecture and the Application Architecture with the Business Architecture. 8. Select an EA framework which aligns with the business and therefore with the environmental strategy. 9. Select environmental standards and frameworks which align with the business strategy and EA. 10. Align business processes with strategic objectives and processes, particularly for environmental sustainability. These should be considered proactively instead of reactively which can result in inefficient and redundant processes. 11. Consider environmental reporting and environmental information requirements when designing or improving all business processes. This is in order to avoid information silos and un-integrated and redundant data. 12. Software applications which support environmental reporting should be preferred. Ensure no duplication of work or data redundancies exist when improving processes for environmental and environmental information management (eliminate silos of information and processes). 13. Environmental data must not be captured more than once. It should be automatically retrieved from the source. 14. Data audits of environmental data should be in place and appropriate controls in place. 15. At the Information Architecture level systems which do not integrate must be avoided at all costs. Only implement an Environmental Management Information System (EMIS) which achieves the standards and best-practice identified in the technology architecture.
Technology level	16. Align the Technology Architecture with the Application, the Information and the Business Architectures. 17. Investigate and select tools and technology that are aligned with all architectures. 18. EA technology should consider best-practice tools and notations which use internationally accepted standards. For example, Business Process Modelling Notation (BPMN), Unified Modelling Language (UML), etc. 19. The environmental sustainability reporting process should be automated wherever possible and retrieval of data should not be a manual process. 20. EMIS should be used which have the minimum functionality: • Stakeholder dialogue; • Web 2.0 based; • Integrated with operational systems and databases; • Online real time access to environmental sustainability information; and • Allows reporting which adheres to standard reporting and compliance.

The verification was marked with an “X” which illustrates that the participants agreed with the question. The participants also had to list success factors for environmental reporting which are similar to the standards identified in the frameworks that they use. These success factors are listed for question five under the survey confirmation questions (Table 6-7).

6.4 Case Study Results

All the participants confirmed the interview questions as well as the guidelines (Table 6-6). All the participants agreed that their organisations use internal Information System (IS) for sustainability environmental information management and reporting (Confirmation question based on survey results – Question 6). All the participants agreed that they have automated storage and retrieval of sustainability information (Confirmation question based on survey results – Question 9). The internationally accepted standards for sustainability reporting were confirmed by six of the participants since their organisations use either Global Reporting Initiative (GRI) or an International Organisation for Standardisation (ISO) standard (Confirmation question based on survey results – Question 4). The participants said that they use the following type of IS for environmental sustainability reporting (Confirmation question based on survey results – Question 7):

- Internal IS (n = 5);
- SAP modules and Metrics Management System (n = 1); and
- Dashboard tool (n = 1).

The participants were asked whether their systems were integrated and three of the participants said "*No*" as their processes were either manual or that some of their systems were isolated (Confirmation question based on survey results – Question 8). One participant (**C07**) said they do not have all their systems integrated. Another participant (**C13**) said that their internal system was integrated but could also be standalone. The other participant (**C04**) said that the process of their reporting is fairly manual at the moment.

The rest of the participants (n = 4) agreed that their systems are integrated wherever possible. All the participants agreed that their EMIS is integrated with their organisation's strategy (Confirmation question based on survey results – Question 10). Three of the participants explained how their EMIS is aligned to their organisation's strategy:

- Participant **C07** said that "*the business will have a strategy both for systems architecture and have a strategy for driving the sustainable development agenda. The two are integrated in the sense that reporting and the database that we use are aligned to the information strategy and those are used to drive a Sustainability effort aligned with a Sustainability strategy*";

- Participant **C14** said that "*it is one of our pillar in-house strategies to sell our brand. We also compute our international carbon footprint. We use a carbon footprint calculator to show the significance of being environmentally friendly*"; and
- Participant **C04** explained that they "*report on an integrated reporting basis, for us it is very important and it is reported at a group level. More important is the integral part of the business philosophy for our extended business division doing short-term insurance"*.

This confirms several studies (Ernst and Young and GreenBiz Group, 2012; KPMG, 2008; Magoulas *et al.*, 2012; Speshock, 2010) and the guideline number two at the strategic level. These studies emphasise the importance of aligning the environmental sustainability strategies to the organisational strategy.

The participants verified that the proposed EA for EIM toolkit could be useful to organisations, and one participant (**C28**) stated that "*these guidelines should be implemented to measure operational ability and the Capability Maturity Model Integration (CMMI) should be used to confirm the level of EA maturity of the different organisations*" (Question based on Toolkit – Question 3). All the participants agreed with the proposed guidelines (Confirmation question based on survey results – Question 1). Two participants proposed additional elements. One participant (**C19**) said that the word 'capabilities' should be used as it is more flexible than the word 'objectives', that is more broad based. Another participant (**C04**) said that there is "*no need to adopt best-practice EA framework rather customise to your needs*" and that "*including the processes of collecting data, ensuring data quality, transformation of data and supply of data*" should be specified on the operational side. This confirms guideline 12 at the operational level. Five participants verified that the toolkit is complete and four of these participants listed additional comments (Question based on Toolkit – Question 5):

- Participant **C28** suggested that "*In order for it to be useful you have to do a broad based (per organisation/per industry) survey to measure your completeness. So I don't think it's complete but if an exercise such as that can be completed then it would be fine to say that it is complete. So I would say no because you don't have supporting facts to prove it*";
- Participant **C20** said that "*It can never be totally complete; I think there will always be more questions coming up as you develop it that will be able to develop further*";
- Participant **C14** proposed that on business architecture: "*specific strategic objectives, goals and Key Performance Indicators (KPI's) should be made more explicit*"; and

- Participant **C04** said it is complete "*with the exception of specifying the data processes in the toolkit*".

All the participants agreed that the proposed EA for EIM Toolkit is consistent. Three participants proposed some additional elements (Question based on Toolkit – Question 6):

- Participant **C28** said that it is consistent "*against something like information best practices and generic architectural standards*";
- Participant **C14** proposed that the toolkit should "*list of all the key applications for environmental sustainability and state the functionality of each*" and that the Information Architecture should "*list key entities and key constructs for environmental and sustainability reporting, for example constructs such as: key risks, key controls, key environmental reporting parameters and key environmental legislative acts*"; and
- Participant **C04** proposed a "*consolidated report on the strategic level and a detailed report on the Management/Operational level*".

The participants communicate their environmental sustainability reports to their external stakeholders on their websites and public websites such as the GRI and JSE websites (Confirmation question based on survey results – Question 11). They also use their intranets and portals to communicate these reports to their internal stakeholders.

Two participants explained that the proposed toolkit could be useful in their organisations if certain exceptions are considered (Question based on Toolkit – Question 4):

- Participant **C07** said that with the "*exception that they would not automate their reporting right up to global level. There are so many almost daily issues on an instrumental level that usually do not have the intelligence to know whether the number is great or not, it's just a number and you really need to build in some guides where those would be rectified before going to the next level. So I would not automate all the way to the top*"; and
- Participant **C14** said their exception would be "*that it should be customised to the specific business*".

Table 6-6: Interview Questions and Responses per Organisation (n = 7)

	ORGANISATION						
	C07	**C28**	**C20**	**C14**	**C13**	**C19**	**C04**
Confirmation question based on survey results:							
1. Do you agree that your company currently has or is expanding your EA?	X	X	X	X	X	X- and in some instances no	X
2. Do you agree that your company has an EA for … number of years?	X – 11-16years	X-over 12-13years	X – 11-16years	X-0-5years	X – 11-16years	X-about 11-years	X-0-5years
3. Your company rated very positive in our survey. Do you agree with this result?	X- Very-Positive	X- Very-Positive	X- Very-Positive	X-Very-Positive	X-Positive	X-Positive	X-Positive
4. Is your company rated on an international standard for environmental or sustainability reporting? If so what is your company's rating and for which standard?	X – GRI standard	Not-sure	X -ISO standard	X -ISO standard	X -ISO standard	X -ISO standard	X-GRI standard
5. [3]							
6. Do you agree that your company uses their own internal IS to manage environmental sustainability information and reporting?	X	X	X	X	X	X	X
7. What systems are used in your company for environmental reporting and Environmental Information Management?	Automatic reporting system internally	All internal IS	Internal IS (SAT)	ISO-Metrics Management System; SAP-Incident Management module; SAP-Waste Management-module; ARIS -Process Repository	Internal IS (Lotus)	Internal IS	Dashboard tool (ClickView)
8. Are your systems integrated wherever possible?	No	X-high level integration	X	X- fully integrated	X-Lotus could be standalone	X	Neutrally manual at the moment
9. Do you have automated storage and retrieval of sustainability information wherever possible?	X	X	X	X	X	X	X-to an extend

[3] Refer to Table 6-7

Table 6-6: Interview Questions and Responses per Organisation (n = 7)(Continued)

	ORGANISATION						
	C07	**C28**	**C20**	**C14**	**C13**	**C19**	**C04**
Confirmation question based on survey results:							
10. Are your EMIS aligned with your organisation's strategy? How is this done?	X	X	X	X	X	X	X
11. Can you also mention how your reports are being communicated to your stakeholders?	Internal stakeholders: on a monthly basis through updates on KPI's External stakeholders: annual reports published through GRI and JSE websites	Internal stakeholders: Business Intelligence (BI) reports External stakeholders: Websites and via mobile applications	Internal stakeholders: use an expression tool External stakeholders: Website	Accessed form website	Internal stakeholders: Intranet External stakeholders: Website	Internal stakeholder: Portal External stakeholders: Website	Internal stakeholders: through interventions and awareness campaigns. External stakeholders: On our website
Question based on toolkit:							
1. Do you agree with the proposed statements/guidelines for organisations which describe the EA for Environmental Information Management toolkit? If not, which statements do you disagree with? Explain the reasons why you disagree.	X	X	X	X	X	X	X
2. [4]Has your company tried to implement any of these guidelines? If yes, have they had successful results?							
3. Do you think the toolkit can be useful to organisations? If not, please explain the reasons why.	X	X	X	X	X	X	X
4. Do you think the toolkit can be useful to your organisation? If not, please explain the reasons why.	X-	X	X	X	X	X-	X
5. Is the toolkit complete? If not, what would you suggest adding?	X			X	X	X	X
6. Is the toolkit consistent? If not, what needs to be made consistent?	X	X	X	X	X	X	X
	TOP 5						
	JSE – LISTED						

[4] Refer to Table 6-8

Table 6-7 shows that some of the participants (n = 3) listed compliance and adherence as a benefit achieved with their EA framework which contributed to their success in environmental reporting (Confirmation questions based on survey results – Question 5). The other four participants listed the following benefits:

- *draw information automatically from the equipment level;*
- *participate in global reporting system;*
- *reduced a lot of learning, they have sort of an inter-organisational standards;*
- *data integrity;*
- *documented evidence;*
- *to ensure transparency and also the biggest thing about the company reputation that if you do your things consistently then your reputation will also increase;*
- *converted data centre into a more green data centre;*
- *very people related; and*
- *committed to create awareness and to measure accurately (fair degree of consciousness).*

Several key themes were identified from the success factors listed by the participants. These key themes included that environmental reporting can assist organisations to be recognised with international standards. Other themes were that an enhanced reputation can be achieved amongst stakeholders and increases transparency of organisational processes. Thus also confirms the theory identified in Chapter 2 (Section 2.3).

Table 6-7: Success Factors for Environmental Reporting

	ORGANISATION						
	C07	**C28**	**C20**	**C14**	**C13**	**C19**	**C04**
Confirmation question based on survey results:							
List 3 points that you think contribute to your success in environmental reporting which are similar to the standards identified in the framework.	• EA right down to technology level • Able to draw information automatically from the equipment level and goes automatically to reporting • Participate in global reporting system although it's not automatic. I think it should not be automatic because if you have any error in your data, you would like to have an opportunity to make sure that whatever you publish is a number you can back, so you need to double-check before publishing	• Adherence to national standards and best practices • Reduced a lot of learning, they have sort of an inter-organisational standards • They had the right people in the right positions. They actually understand the business. Like an architect usually has to go through stages inside the business standards to get to the post (architect understands the business intimately)	• Data integrity • We have an external company verifying the data • Documented evidence	• Especially EN reporting we are adhering to the ISO 27000 and ISO 14000 for basic EN reporting • There is a number of legislative requirements that we must adhere to e.g. there is a number of acts they pertain to things like diesel spills, waste, handling of hazardous materials when there is an incident • We have detailed procedures and processes that are published on our intranet that are available to all employees	• Culture of compliance with all the legal and other regulatory requirements • To ensure transparency and also the biggest thing about the company reputation that if you do your things consistently then your reputation will also increase	• Achieved power consumption reduction stipulated framework • Converted data centre into a more green data centre	• It is very people related, the sustainability manager has to want to do a measurement • People that is involved from a functional perspective is much more committed to create awareness and to measure accurately(fair degree of consciousness) • The short-term insurance division have adopted environmental management as strategically core to their business as claims are being paid when there are environmental disasters, climate change, storms etc. and they have adopted it almost fully

During the interview process the participants were asked to verify (Table 6-8) the proposed guidelines (Question based on Toolkit – Question 2). Almost all the participants verified that the majority of the guidelines have been or could be implemented in their organisations and other organisations. One participant (**C07**) could not verify whether they use an internationally accepted EA framework (Guideline – Strategic Level: No.1). This participant also said that they do not "*necessarily align our processes to favour environmental sustainability*" (Guideline – Operational Level: No.4). Another participant (**C013**) could not verify whether they use EA to align their business-IT and environmental strategies (Guideline – Strategic Level: No.5). The guideline for the information architectures level systems which do not integrate must be avoided at all costs could not be verified by a participant (**C13**), as they said "*sometimes some systems don't necessarily integrate but they serve a particular purpose. It could be for us to use the system internally or something that can be used to serve a customer purpose*" (Guideline – Operational Level: No.9).

Table 6-8: Verification of Guidelines per Organisation

Organisation	**C07**	**C28**	**C20**	**C13**	**C19**	**C04**	**C14**
Guideline							
Strategic Level							
1. Use an internationally accepted EA framework.	No comment/Unsure	X	X	X	X	X	X
2. The EA strategy and objectives must consider environmental sustainability strategic objectives.	X	X	X	X	X	X	X
3. When considering the potential benefits of EA an organisation needs to consider the benefits to all stakeholders of environmental initiatives and environmental reporting.	X-but focusing primarily on internal stakeholders, for example employees, suppliers, shareholders and others	X	X	X	X-in the process	X	X
4. Identify potential challenges and risks of environmental reporting in EA. these can be used to reduce risks.	X	X	X	X	X	X	X
5. Use EA to align IT and business and therefore IT and environmental strategy.	X	X	X	Unsure	X	X	X
6. At the strategic level the Business Architecture level of the EA must be considered.	X	X	X	X	X	X	X

Table 6-8: Verification of Guidelines per Organisation (Continued)

Organisation	**C07**	**C28**	**C20**	**C13**	**C19**	**C04**	**C14**
Guideline							
Operational Level							
7. Align the Information Architecture and the Application Architecture with the Business Architecture.	X	X	X	X	X	X	X
8. Select an EA framework which aligns with the business and therefore with the environmental strategy.	X	X	X	X	X	X	X
9. Select environmental standards and frameworks which align with the business strategy and EA.	X	X	X	X	X	X	X
10. Align business processes with strategic objectives and processes, particularly for environmental sustainability. (These should be considered proactively instead of reactively which can result in inefficient and redundant processes.)	No, we don't necessarily align our processes to favour environmental sustainability	X	X	X – To a degree	X	X	X
11. Consider environmental reporting and environmental information requirements when designing or improving all business processes. This is in order to avoid information silos and un-integrated and redundant data.	X	X	X	X – To a degree for business process engineering	X	X	X
12. Software applications which support environmental reporting should be preferred. Ensure no duplication of work or data redundancies exist when improving processes for environmental and environmental information management (eliminate silos of information and processes).	X	X	X	X	X	X	X
13. Environmental data must not be captured more than once. It should be automatically retrieved from the source.	We do capture more than once	X	X	X	X	X	X
14. Data audits of environmental data should be in place and appropriate controls in place.	X	X	X	X	X	X	X
15. At the Information Architecture level systems which do not integrate must be avoided at all costs. Only implement an EMIS which achieves the standards and best-practice identified in the technology architecture.	Not necessarily avoided at all costs. Best-practice only required right at the end and not in the process of getting data	X	X		X	X	X

Table 6-8: Verification of Guidelines per Organisation (Continued)

Organisation	**C07**	**C28**	**C20**	**C13**	**C19**	**C04**	**C14**
Guideline							
Technology Level			**In development process, but yes to all**				
16. Align the Technology Architecture with the application, the Information and the Business architecture.	X	X	X	X	X	X	X
17. Investigate and select tools and technology that are aligned with all architectures.	X	X	X	X	X	X	X
18. EA technology should consider best-practice tools and notations which use internationally accepted standards. For example, BPMN, UML, etc.	X	X	X	X	X	X	X
19. The environmental sustainability reporting process should be automated wherever possible and retrieval of data should not be a manual process.	X	X	Some manual processes exist	X – To a degree	X	X	X
20. EMIS should be used which have the minimum functionality: • Stakeholder dialogue; • Web 2.0 based; • Integrated with operational systems and databases; • Online real time access to environmental sustainability information; and • Allows reporting which adheres to standard reporting and compliance.	EMIS is connected real time to equipment where possible	X	X	X-To a degree especially on Web 2.0, although we getting there it's not really fully there	X	It is still a manual process	X-Our EMIS = combination of (ISO-Metrics Management System; ARIS -Process Repository; SAP-Incident Management module; SAP-Waste Management module)

6.5 Conclusions

This chapter successfully achieved the research objective six (RO6): *"To identify the practices of successful South African organisations with regard to the use of Enterprise Architecture for supporting environmental sustainability reporting"*. The research objective six (RO6) successfully answered the sixth research question for this chapter: RQ6: "*How are successful South African organisations using Enterprise Architecture to support environmental sustainability reporting and Environmental Information Management?"*

This chapter addressed the findings from seven organisations that follow best-practice processes using EA to support environmental sustainability reporting and EIM processes were chosen from the survey study sample to participate in the case study. The case study findings showed that these organisations uses internationally accepted EA frameworks and environmental sustainability standards which contribute to their EA and environmental sustainability reporting and EIM processes.

These organisations also align their environmental sustainability reporting and EIM strategies to the organisation's business and IT strategies. Automated storage and retrieval of environmental sustainability data is another key success factor which is directly linked to the integration of their EMIS systems to the other organisational systems. Communication with their stakeholders is important and this is achieved through using intranets, portals, their websites and public websites.

The key findings were that the proposed guidelines were verified and the EA for EIM Toolkit (Version 2) in Chapter 5 (Figure 5-18) was verified to be useful for organisations in most cases (Section 6.4). The participants from these organisations proposed some additional elements that can be taken into consideration for the toolkit. They also identified future aspects to enhance the operating ability of the toolkit. It was proposed that the following elements be added to the EA for EIM Toolkit (Version 2) in Chapter 5 (Figure 5-18):

- On the Business Architecture: specific strategic objectives, goals and KPI's should be made more explicit;
- Produce a consolidated report on the strategic level and detailed report on the Management/Operational level;
- List of all the key applications for environmental sustainability and state the functionality of each and that Information Architecture should include all key entities and key constructs for environmental and sustainability reporting, for example

constructs such as: key risks, key controls, key environmental reporting parameters and key environmental legislative acts; and

- Include the processes of collecting data, transformation of data, ensuring data quality and supply of data should be specified on the operational side.

The following proposed elements will be considered for future research:

- In order for the toolkit to be useful you have to do a broad based (per organisation/per industry) survey to measure completeness;
- The guidelines should be implemented to measure operational ability and the CMMI should be used to confirm the level of EA maturity of the different organisations.

The updated EA for EIM Toolkit (Version 3) reflects the elements in the colour purple that are added from the case study findings (Figure 6-3). It is proposed that the use of the toolkit should be seen as a guideline that can be customised to the needs and specifications of a particular organisation. The key contribution that can be achieved with this toolkit is that the organisations can view how to align their business-IT and environmental sustainability reporting and EIM strategies. Specific elements were identified that can be used directly depending on the type of business operations, such as the challenges that organisations can be aware of and the applications and tools and technologies that can be used for EA design and environmental sustainability reporting and EIM.

The next chapter will present the conclusions of the research study and make recommendations. The research objectives achieved will be illustrated and the significant theoretical and practical contributions made in this study will be described.

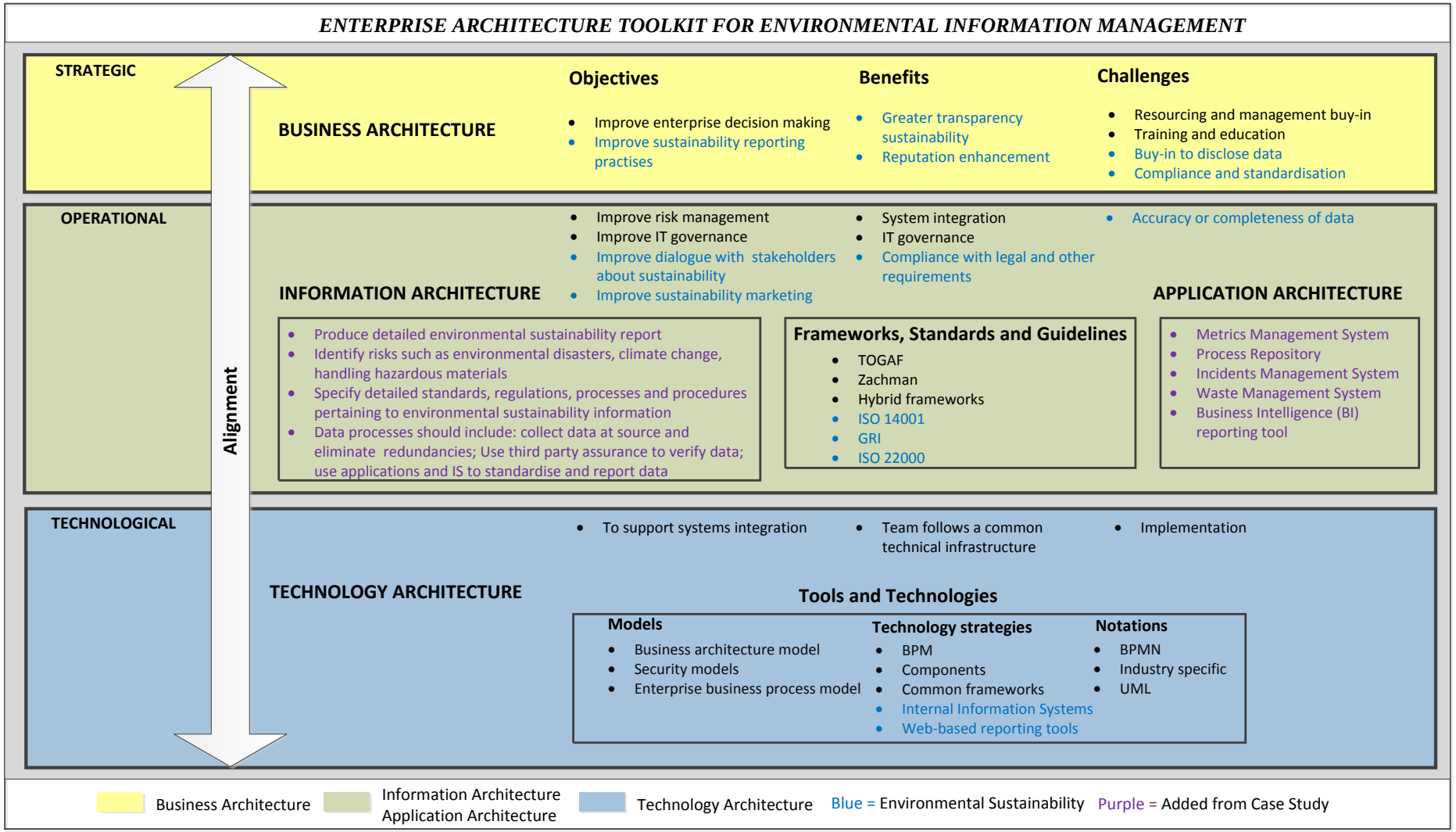


Figure 6-3: EA for EIM Toolkit (Version 3)

Chapter 7 Conclusions and Recommendations

7.1 Introduction

The demand for environmental sustainability reports is increasing globally and in particular in South Africa (Section 1.1.1). Research indicates that more South African organisations from all sectors should produce an integrated sustainability report which should include their economic, social and environmental position. The purpose of these reports is to disclose the position of the organisation to its stakeholders such as investors, suppliers, customers, and to the broader public. It has now been legislated that the public has the right to information regarding environmental impact. However it is shown that organisations are facing many problems when it comes to environmental sustainability information management. These problems are locating, accessing, processing, analysing, recording and presenting such information in a standardised format across all departments and divisions in an organisation. The reason for these issues is that the information is kept in different places and is not managed and captured at the source of the information in an integrated information system (IS) and as a result "silos" exist. These problems are also linked to a lack of alignment between the organisational strategies, the information technology (IT) strategies and the environmental sustainability strategies.

Research shows that one use for and the purposes of EA are for business-IT alignment (Section 1.1.2). EA is also referred to as a blueprint which can outline the guidelines of an organisation. EA adoption amongst South African organisations has been slow due to the skills shortage and as the EA budget is not a priority. However the adoption rate for the EA framework namely, The Open Group Architectural Framework (TOGAF) amongst South African organisations has increased tremendously over the past few years and South Africa is ranked seventh globally for the number of TOGAF certifications.

One of the research objectives of this study was to investigate and describe the status of environmental and sustainability reporting as well as the status of EA adoption in organisations. This was achieved through the use of a survey strategy (Chapter 5). Furthermore the main research objective of this study was to investigate and propose the use of an EA for supporting environmental sustainability strategies and environmental information management (EIM) and reporting (Section 1.5). This was achieved through the use of a case study strategy (Chapter 6).

This study proposes an EA Toolkit for EIM and business-IT alignment based on the TOGAF EA Content Metamodel design (Section 3.2.2) which is reflected in the EA Components Model (Section 3.9). A set of guidelines for EA for EIM Toolkit has been designed and proposed in this study for organisations to use in order to align their organisational, IT and environmental sustainability strategies (Section 6.4).

The chapter structure is shown for this study (Figure 7-1). This chapter will further outline how the research objectives were achieved (Section 7.2). A theoretical contribution and a practical contribution were made in this study (Section 7.3). However there were limitations and problems that were encountered throughout achieving this study (Section 7.4). During the process of completing this study, future research aspects were also identified (Section 7.5). The key contributions of this study is summarised (Section 7.6).

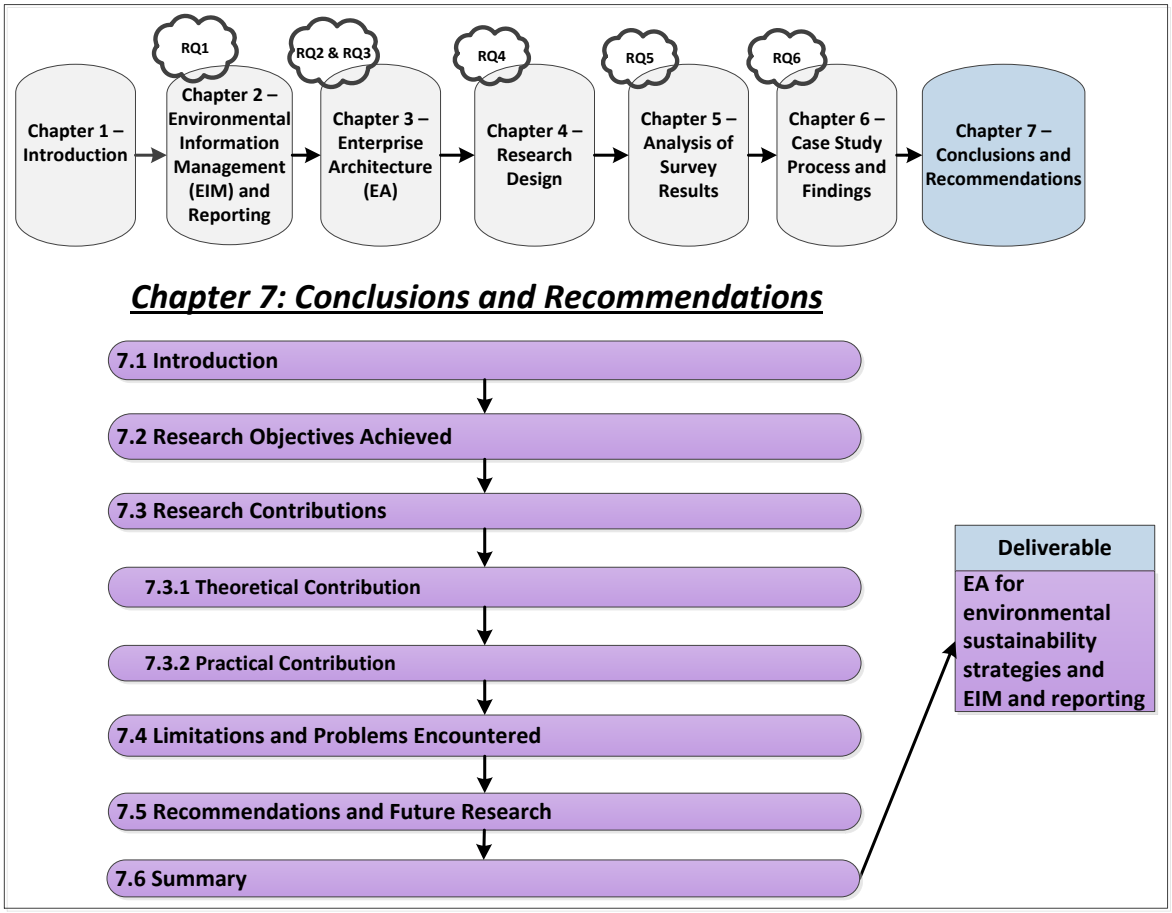


Figure 7-1: Chapter 7 Structure

7.2 Research Objectives Achieved

The main objective of this study was: "*To investigate and propose the use of an Enterprise Architecture for supporting environmental sustainability strategies and Environmental Information Management and reporting in organisations"*. Six secondary research objectives (ROs) were identified in order to achieve the main objective namely:

RO1: To investigate and describe the status of environmental and sustainability reporting in organisations relating to (Chapter 2):

- The objectives, benefits and challenges of sustainability reporting for organisations;
- The standards, tools and technologies implemented by organisations for sustainability reporting; and
- The requirements for Environmental Information Management and environmental reporting.

RO2: To identify the objectives, benefits and challenges of Enterprise Architecture adoption in organisations (Chapter 3).

RO3: To identify the frameworks, tools and technologies adopted for Enterprise Architecture in organisations (Chapter 3).

RO4: To identify and apply a suitable research methodology for this study (Chapter 4).

RO5: To investigate Enterprise Architecture and environmental sustainability reporting practices in South African organisations (Chapter 5).

RO6: To identify the practices of successful South African organisations with regards to the use of Enterprise Architecture for supporting environmental sustainability reporting (Chapter 6).

Different research questions were created to address the relevant research objectives. The main research question for this study was:

"*How can Enterprise Architecture be used to support environmental sustainability strategies and environmental information management and reporting in organisations?"*. Table 7-1 illustrates the secondary research questions which are derived from the main research question, the research objectives and the relevant chapters where these were addressed.

Table 7-1: Research Questions and Chapters Addressing the Questions

Research Question		Chapter	Research Objective
RQ1	What is the status of environmental and sustainability reporting in organisations relating to: • What are the sustainability reporting strategies (objectives, benefits and challenges) for organisations? • What are the standards, tools and technologies implemented by organisations for environmental sustainability reporting? • What are the requirements for Environmental Information Management and environmental reporting?	2	RO1
RQ2	What are the objectives, benefits and challenges of Enterprise Architecture adoption in organisations?	3	RO2
RQ3	What are the frameworks, tools and technologies adopted for Enterprise Architecture in organisations?	3	RO3
RQ4	What is a suitable research methodology for this study?	4	RO4
RQ5	What are South African organisations doing with regard to Enterprise Architecture and environmental sustainability reporting?	5	RO5
RQ6	How are successful South African organisations using Enterprise Architecture to support environmental sustainability reporting and Environmental Information Management?	6	RO6

The first research objective (RO1) was achieved as the status of environmental and sustainability reporting in organisations was identified (Chapter 2). The status of the objectives (Section 2.2), benefits (Section 2.3) and the challenges (Section 2.4) were verified amongst the South African organisations that participated in the survey study (Section 5.4.1 and 5.4.2). The three highest rated objectives, benefits and challenges to these participants were identified (Table 7-2).

Table 7-2: Status of Environmental Sustainability Reporting

Objectives	Improve sustainability reporting practices Improve dialogue with stakeholders about sustainability Improve sustainability marketing
Benefits	Compliance with legal and other requirements Reputation enhancement Greater transparency
Challenges	Quality of data Buy-in to disclose data sustainability Compliance and standardisation

The second part of the first research objective (RO1) was achieved, since the standards (Section 2.5) and the tools and technologies (Section 2.6) for environmental sustainability reporting were identified within organisations. Table 7-3 illustrate those organisations that participated in the EIM questionnaire, verified and rated the standards, tools and technologies that are used in their organisations (Section 5.4.1).

Table 7-3: Standards, Tools and Technologies Used

Standards	International Organisation for Standardisation (ISO) 14001 Global Reporting Initiative (GRI) Environmental Management System (EMS)
Tools and Technologies	Excel Internal Information Systems Web-based reporting tools

The last aspect of research objective one (RO1) was to identify the EIM and environmental reporting requirements (Section 2.7). This was achieved as the main environmental (EN) information indicators for an environmental report were verified amongst the participating organisations (Section 5.4.1). Eight EN indicators were selected from a list of 30 EN indicators and were included in the EIM questionnaire. Five of the eight EN indicators were represented and rated in order of importance by the participants (Table 7-4).

Table 7-4: EN indicators

EN3	Direct energy consumption by primary energy source
EN18	Initiatives to reduce greenhouse gas emissions and reductions achieved
EN16	Total direct and indirect greenhouse gas emissions by weight
EN4	Indirect energy consumption by primary source
EN8	Total water withdrawal by source

Other EIM requirements that were identified from theory were (Section 2.7 and Table 2-5):

- The relevant environmental information must be presented to the relevant stakeholders as different stakeholders have different information needs;
- Environmental information is a source needed in organisations especially for strategic decision-making processes;
- The environmental information can reflect whether organisations are responsible citizens; and
- Environmental information should meet compliance, standards and regulations such as for auditing procedures.

The second research objective (RO2) was achieved as the EA objectives (Section 3.3), EA benefits (Section 3.4) and EA challenges (Section 3.5) were identified in organisations from theory. The South African organisations that participated in the EA questionnaire empirically validated these objectives, benefits and challenges. Table 7-5 illustrates the top three rated EA objectives, EA benefits and EA challenges by these organisations in the industry survey (Section 5.3.2).

Table 7-5: EA Elements

Objectives	Improve risk management Improve IT governance Support system integration Improve enterprise decision making
Benefits	System integration IT governance Team follows a common technical infrastructure
Challenges	Resourcing and management buy-in Training and education Implementation

Research Objective three (RO3) was achieved as the frameworks (Section 3.1), models and modelling notations (Section 3.6) and the tools and technologies (Section 3.7) of EAs used by organisations were identified (Section 5.3.2). The participants by means of the EA questionnaire verified and rated these EA frameworks and tools and technologies that are used in their organisations. Table 7-6 illustrates the highest rated frameworks, models, modeling notations and the technology strategies of EA in these organisations.

Table 7-6: Frameworks, Tools and Technologies Adopted for EA

Frameworks	TOGAF Zachman Hybrid frameworks
Models	Business architecture model Security models Enterprise business process model
Notations	Business Process Modelling Notation (BPMN) Industry specific UML
Technology strategies	Business Process Management (BPM) Components Common frameworks

Research objective four (RO4) was achieved as an appropriate research methodology was identified and applied to this study (Chapter 4). The interpretivist and positivist philosophies were adopted in this study. Interpretivism, was chosen as the research is evident in real world business scenarios. The positivist approach was adopted since this philosophy encourages the exclusion of the researcher involvement in the data collection process during the survey strategy which involved online questionnaires. The research strategies adopted in this research were the case study and survey study strategies which involved qualitative and quantitative data collection such as interviews and questionnaires.

Research objective five (RO5) was achieved as it investigated what South African organisations are doing with regard to EA and environmental sustainability reporting (Section 5.4 and 5.5). A large number (42%) of organisations that participated in the EA and EIM questionnaires agreed that they do take into account environmental sustainability information when they design their EA. These organisations also agreed that one of their overall EA objectives was to overcome their environmental concerns.

The sixth research objective (RO6) was achieved as all the participating organisations from the survey study were ranked on their overall response based on how successful these South African organisations are in using EA to support environmental sustainability reporting (Section 6.2). The top five ranked organisations as well as two other organisations that were willing to participate were chosen to partake in a case study where they were interviewed and had to verify the proposed guidelines (Section 6.4) and the EA for EIM Toolkit (Version 2).

7.3 Research Contributions

The achievement of the research objectives allowed for significant research contributions. Theoretical and practical contributions were established. The theoretical contributions (Section 7.3.1) were illustrated using the theoretical findings of this study. The practical contributions (Section 7.3.2) were based on best-practice guidelines in the field of EA and environmental sustainability practices where a toolkit is proposed that can be used by different organisations from different industries to help them align their organisational, IT and environmental sustainability strategies.

7.3.1 Theoretical Contribution

The theoretical contribution of this study is based on three main aspects. The first aspect was to identify in literature the status of environmental sustainability and EIM and reporting (Chapter 2). For this reason a model was designed that represents all the components (Figure 7-2). The second aspect was to identify the theory regarding the frameworks, tools and technologies for EA used in organisations (Chapter 3). These components are represented using the proposed model (Figure 3-9). The third aspect of the theoretical contribution of this study was to illustrate how EA can support environmental sustainability and EIM and the reporting aspects identified in this study. This third aspect is also represented by using the proposed model (Figure 3-10).

A model which includes the process levels, the mission and work processes of organisations was identified in literature (Section 2.8) and this study adapted the model to map each level to the relevant aspects of the environmental sustainability and EIM reporting components (Figure 7-2). The environmental and sustainability reporting objectives, benefits, challenges as well as the tools and technologies that were identified in Chapter 2 are divided into the three process levels namely, strategic, operational and technological levels. These levels were used throughout this study to emphasise the alignment of the organisational, IT and environmental sustainability strategies.

Figure 7-3 was formulated in Chapter 3 (Section 3.9) and includes all the aspects that are addressed in literature regarding EA in this study. The four main EA components namely, Business Architecture, Information Architecture, Application Architecture and Technology Architecture are evident in this model and the alignment aspect between the process levels is illustrated. It is clear that this model also illustrates the alignment between the organisational, IT and Environmental Management Information Systems (EMIS) features.

A model was designed in this study which included both the EA and environmental sustainability and EIM and reporting aspects and proposed the concept of EA support for EIM and reporting (Section 3.10). This model (Figure 3-10) is called EA for EIM Toolkit (Version 1) as it is the first version of the proposal for EA support for EIM in this study. The EA for EIM Toolkit (Version 1) shows that all aspects regarding EA and EIM and environmental sustainability reporting should be integrated and that the organisational, IT and environmental sustainability strategies should be aligned.

ENVIRONMENTAL SUSTAINABILITY REPORTING COMPONENT MODEL

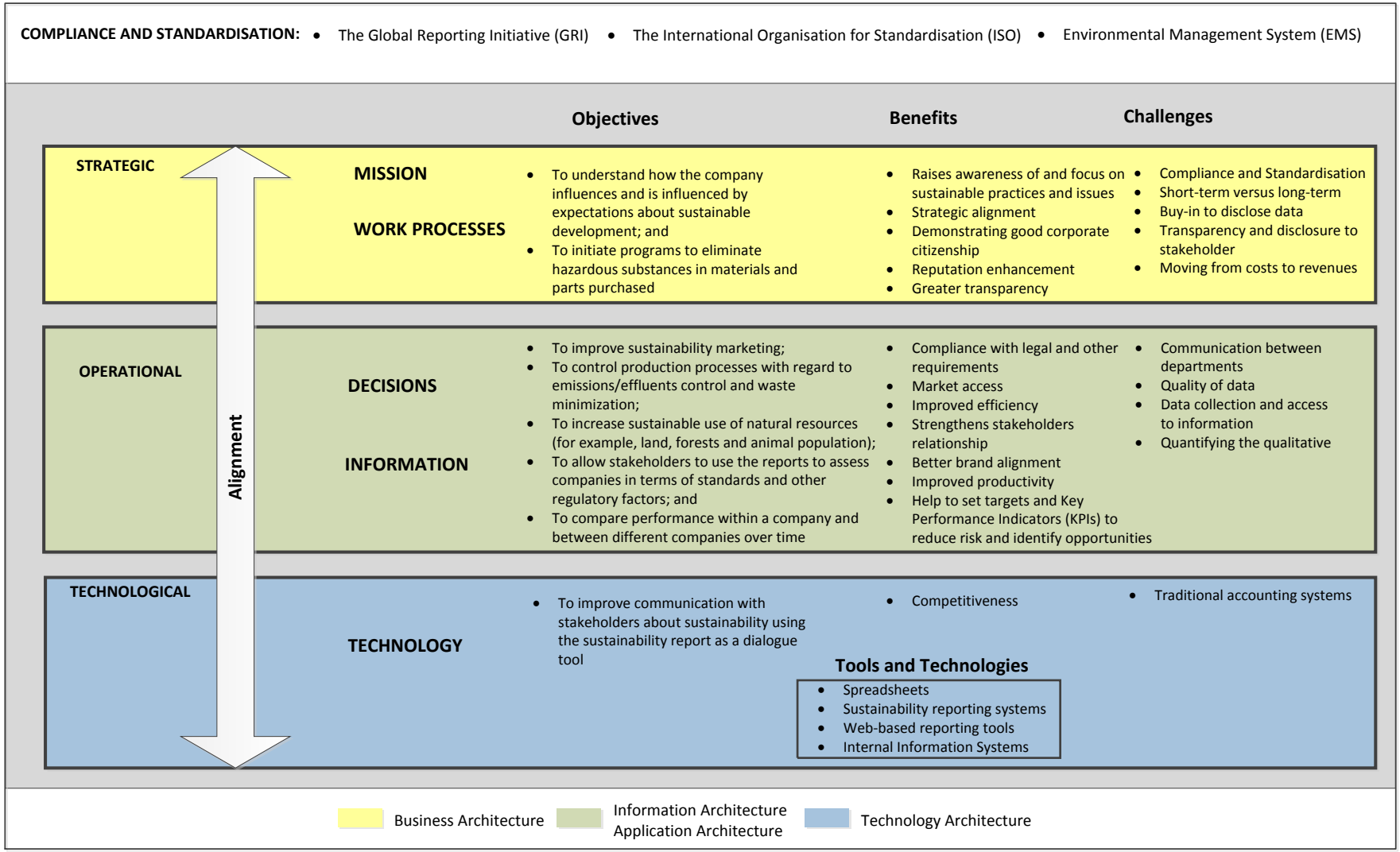


Figure 7-2: Environmental Sustainability Reporting Component Model

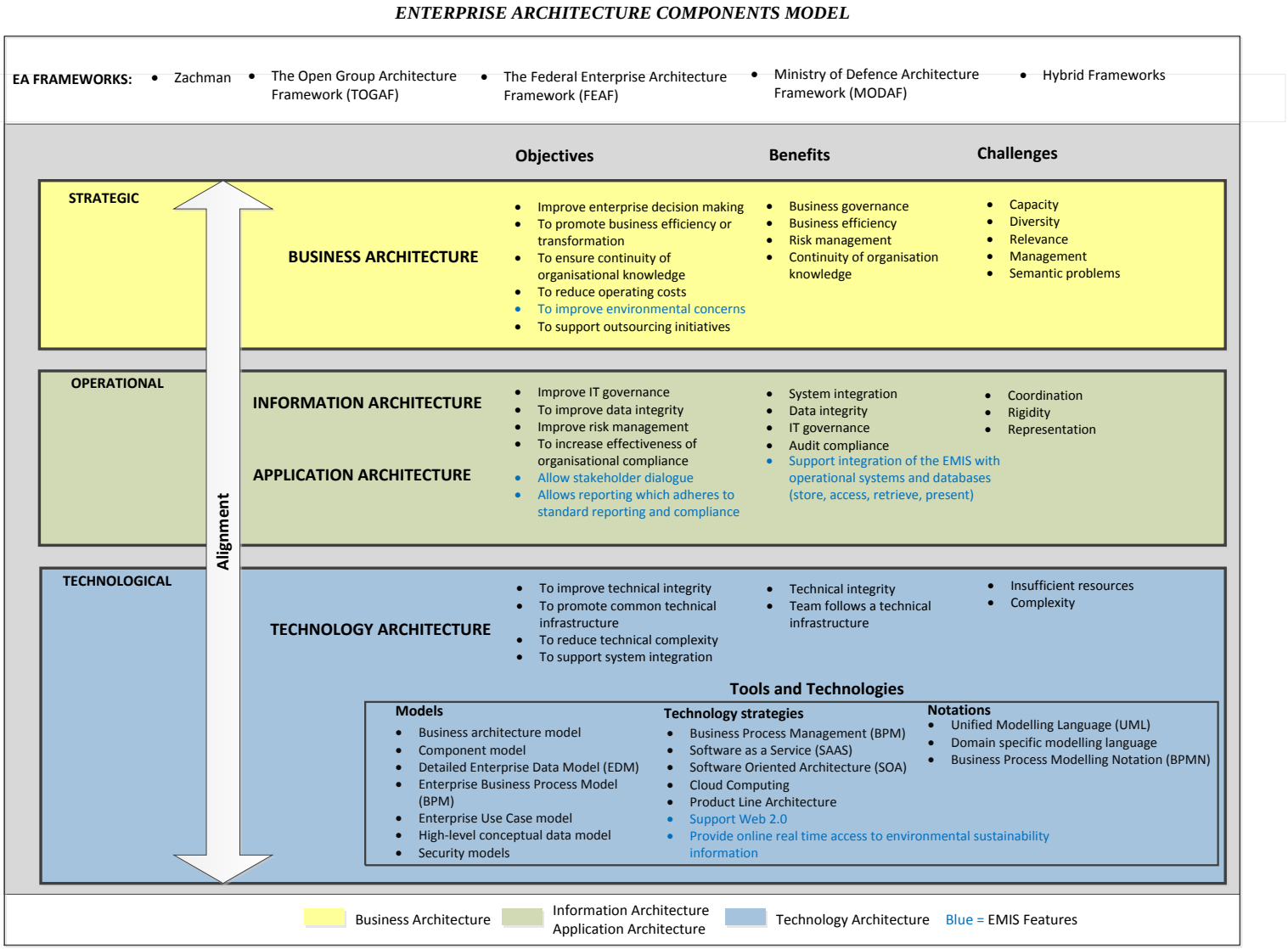


Figure 7-3: EA Components Model

The theoretical contribution of this study will be used to illustrate how the practical contribution was formulated for this study. The EA for EIM Toolkit (Version 1) is used to show how the toolkit was updated throughout this study which represents the findings from the survey study (EA for EIM Toolkit Version 2) as well the findings from the case study (EA for EIM Toolkit Version 3).

7.3.2 Practical Contribution

The practical contribution of this study includes two main aspects. The first aspect is that the EA for EIM Toolkit (Version 1) components had to be verified in the survey study (Chapter 5). All the highest rated results from the EA and EIM questionnaires were then included in the EA for EIM Toolkit (Version 2) which was introduced in Chapter 5(Section 5.7). The survey study results were also used to identify the top five organisations based on their overall response for both questionnaires (Section 6.2).

The second aspect of the practical contribution of this study is that guidelines for the EA for EIM Toolkit (Version 2) were proposed based on literature (Table 6-5). These guidelines and the EA for EIM Toolkit (Version 2) were verified by the top five organisations that participated in the case study based on their best-practice (Section 6.4). The EA for EIM Toolkit Version 2 was then updated to EA for EIM Toolkit Version 3 (Figure 7-4) based on the findings from the case study and the updates from the case study are represented in the colour purple.

It was proposed by the organisations that participated in the case study that capabilities should form part of objectives as having capabilities is more specific and objectives include a broad-based aspect. Examples of capabilities were given such as to "*Produce consolidated environmental sustainability report*" on the strategic level for executive management and to "*Specify specific Key Performance Indicators (KPI's)*". The participants also proposed specific elements that should be considered under the information and application architectures. Examples of elements that should be considered under the Information Architecture are to "*Produce detailed environmental sustainability report*" for management on the operational level and specify all the data processes involved in the EIM and reporting process. Different types of IS and tools were also identified under the application architecture that can assist with the EIM and reporting requirements.

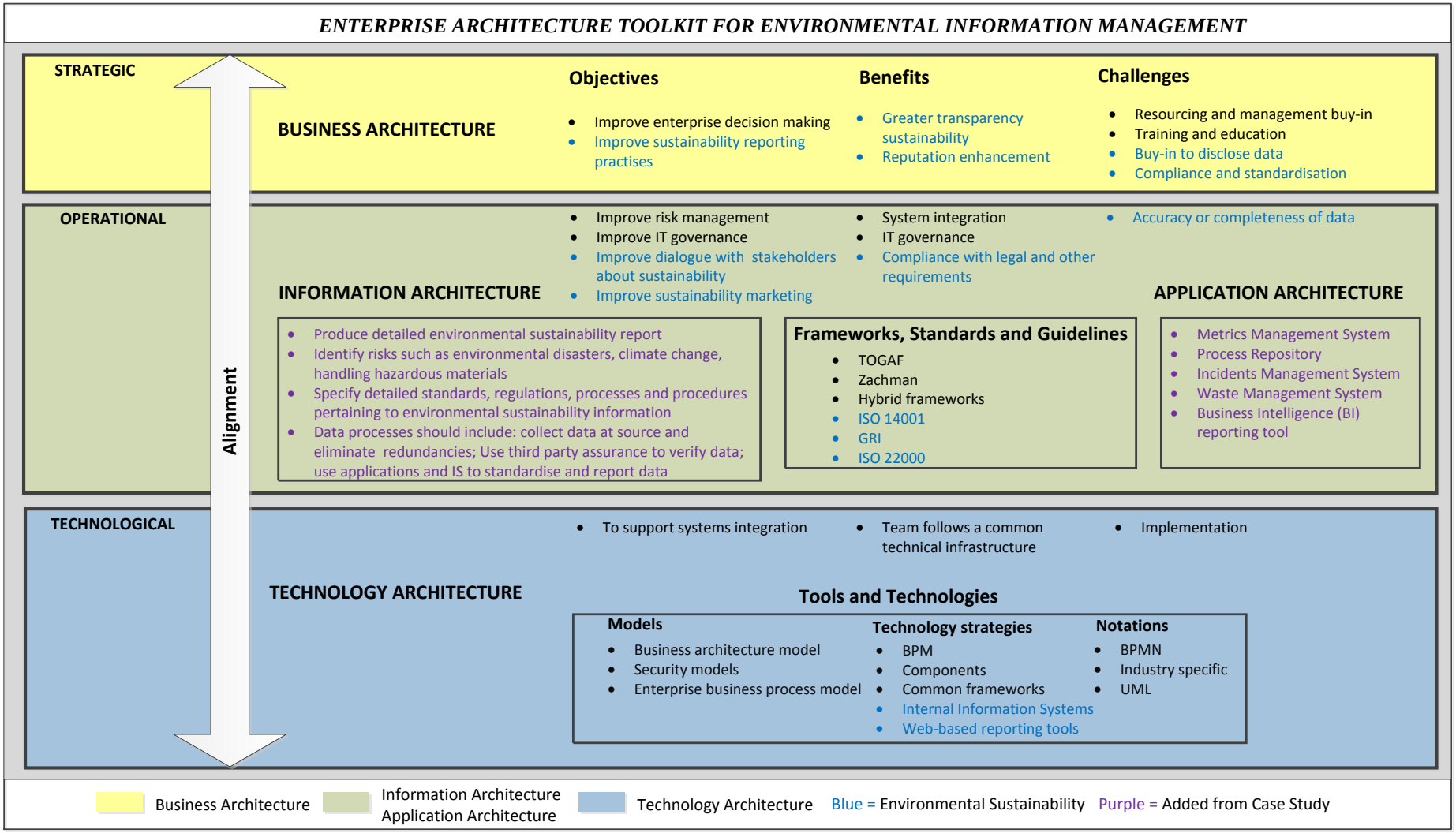


Figure 7-4: EA for EIM Toolkit (Version 3)

7.4 Limitations and Problems Encountered

The limitation of the survey study was that only a certain number of questions could be asked to prevent the survey from being too lengthy (Saunders *et al.*, 2009)**.** This survey study was supported by a case study to overcome this limitation. The case study was used to address the more in-depth questions that could not be covered by the survey study. Another challenge of survey study was the response rate of this study (17%). Hatch (2009) reports that surveys in general are lucky to receive a 10% response rate.

Other limitations of this study were that respondents from industry were required to take part in completing the questionnaires in the survey study. Only 31 participants took part in the survey study after contacting a target of 182 participants via email. A number of participants from the 31 participants sometimes took longer than two months to respond and to complete the questionnaires.

A smaller subset of these respondents was selected to take part in the detailed case study process. Research shows that working with respondents from industry can cause some difficulties (that is to get the respondents to commit to completing the questionnaires and being part of the case study process). This implication prolonged the survey study which caused postponing some elements of the project plan. There were times where the respondents were required to do follow-up interviews for incomplete responses to the survey.

The study was limited by the constraints of getting the targeted sample of participants to complete the questionnaires. The small sample size made it difficult to perform statistical tests concerned with comparing the industry groups that participated, therefore limited statistical significance resulted.

7.5 Recommendations and Future Research

The results of this study have shown the importance of EA research particularly in South Africa. It is recommended that future studies can investigate the implementation of the EA for EIM Toolkit Version 3 in organisations. It is also recommended that this study should be repeated with a larger sample and with a larger number of non- Johannesburg Stock Exchange (JSE) listed organisations.

Studies could be undertaken which compare South African organisations with organisations in other countries. More research is required regarding the implementations of sustainability reporting tools in organisations and the critical success factors of these implementations. Studies of maturity models such as the Capability Maturity Model Integration (CMMI) could also be undertaken to confirm the level of EA maturity of the different organisations.

7.6 Summary

This research achieved the research objectives identified in Chapter 1. The participants from the case study agreed that the proposed guidelines for the EA for EIM Toolkit could be used for the purpose of alignment between the organisation, IT and EIM and reporting strategies. The research achievements also included the following:

- Identification of the status of environmental and sustainability reporting amongst South African organisations;
- Identification of EA adoption in South African organisations;
- The benefits and challenges that South African organisations face with EIM and reporting as well as with EA;
- Identification of tools and technologies which can support EIM and reporting;
- Success factors identified by South African organisations for environmental reporting;
- A set of guidelines based on best-practice in South African organisations for the use of EA for EIM and reporting; and
- The EA for EIM Toolkit which supports the alignment of the organisation's objectives for EA and EIM and reporting, with the organisation and with IT.

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Appendix A – Ethical Clearance Document

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

Nelson Mandela Metropolitan University

for tomorrow

Chairperson of the Faculty RTI Committee (Faculty of Science)
Nelson Mandela Metropolitan University
Tel: +27(0)41 - 504 2268 Fax: +27(0)41 - 504 2369

Ref: H12-Sci-CS-018 **Contact person:** Mrs L Roodt

Student No: 207026467 Date: 12 October 2012

Anthea Connolley
50 Reynders Street
Arcadia
Port Elizabeth
6059

Dear Connolley

TITLE OF PROJECT: AN INFORMATION ARCHITECTURE FOR ENVIRONMENTAL MANAGEMENT

Your above-entitled application was considered and approved by the Sub-Committee for Ethics approval in the Faculty of Science on 12 October 2012.

The Ethics clearance reference number is **H12-Sci-CS-018**, and is valid for three years. Please inform the FRTI Committee, via your faculty officer, 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

pp

Chairperson: Faculty Research, Technology and Innovation Committee
(Faculty of Science)

cc: Department of Research Capacity Development
Faculty Officer, Faculty of Science

Appendix B – GRI G4 Environmental (EN) Indicators

ASPECT: MATERIALS

- EN1 Materials used by weight or volume.
- EN 2 Percentage of materials used that are recycled input materials.

ASPECT: ENVIRONMENTAL ENERGY

- EN3 Direct energy consumption by primary energy source.
- EN4 Indirect energy consumption by primary source.
- EN5 Energy saved due to conservation and efficiency improvements.
- EN6 Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives.
- EN7 Initiatives to reduce indirect energy consumption and reductions achieved.

ASPECT: WATER

- EN8 Total water withdrawal by source.
- EN 9 Water sources significantly affected by withdrawal of water.
- EN10 Percentage and total volume of water recycled and reused.

ASPECT: BIODIVERSITY

- EN11 Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.
- EN12 Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.
- EN13 Habitats protected or restored.

- EN14 Strategies, current actions, and future plans for managing impacts on biodiversity.
- EN15 Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.

ASPECT: EMISSIONS, EFFLUENTS, AND WASTE

- EN16 Total direct and indirect greenhouse gas emissions by weight.
- EN17 Other relevant indirect greenhouse gas emissions by weight.
- EN18 Initiatives to reduce greenhouse gas emissions and reductions achieved.
- EN19 Emissions of ozone-depleting substances by weight.
- EN21 Total water discharge by quality and destination.
- EN22 Total weight of waste by type and disposal method.
- EN23 Total number and volume of significant spills.
- EN24 Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, and VIII, and percentage of transported waste shipped internationally.
- EN25 Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.
- EN26 Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.
- EN27 Percentage of products sold and their packaging materials that are reclaimed by category.

ASPECT: COMPLIANCE

- EN28 Monetary value of significant fines and total number of non-monetary sanctions for non- compliance with environmental laws and regulations.

ASPECT: TRANSPORT

- EN29 Significant environmental impacts of transporting products and other goods and materials used for the organization's operations, and transporting members of the workforce.

ASPECT: OVERALL

- EN30 Total environmental protection expenditures and investments by type.

Appendix C – ITEE 2013 Conference Paper (Chapter in Springer book)

Enterprise Architectures for Addressing Sustainability Silos

Brenda Scholtz, Anthea Connolley, Andre Calitz

Abstract A need exists for behaviour change and transparency in modern organisations where the focus needs to shift towards sustainability thinking rather than just sustainability reporting for compliance reasons. The number of organisations which are undertaking Green Initiatives and reporting on sustainability are increasing. However many of these organisations are not viewing these initiatives strategically. The effect on information requirements and business processes is often not considered and the available tools and technologies are not used to their full potential. As a result, whilst sustainability reports are produced, the underlying infrastructure consists of "sustainability silos" comprising of a lack of integrated systems, inconsistent data and information where the integrity is not reliable.

In order to address these issues this study investigates the extent to which organisations consider environmental information requirements and processes when planning their information systems and Enterprise Architecture (EA). The inclusion of Green Initiative strategies into the design of an organisation's enterprise systems and EA is proposed. This will ensure alignment between environmental management and IT planning and result in integrated systems, an improved sustainability reporting process and more effective decision-making regarding the environmental impact of organisations.

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Appendix D – IBC 2013 Conference Paper

Achieving the Benefits of Business-IT Alignment Supported by Enterprise Architecture

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ABSTRACT

In a global, digitised economy, organisations in all sectors have become progressively more dependent on Information Technology (IT). It is critical that this dependency is effectively managed and for this reason, several approaches such as IT governance, IT risk management, business process management (BPM) and Enterprise Architecture (EA) frameworks have been proposed. IT is often seen not to meet business expectations and one of the reasons for this is a lack of Business-IT alignment. The alignment of IT and business strategies is, therefore, becoming more essential in organisations since most processes within a business require IT assistance. Research shows that organisations struggle to achieve this. This paper proposes the use of an Enterprise Architecture (EA) framework to achieve the alignment between IT and business. Using an EA framework to align the organisational and IT strategies is beneficial as the EA framework covers the organisational, operational and technical aspects of an organisation. Having a single repository which contains a holistic view of all strategies, processes, plans and technologies can help organisations to better manage their operations.

Empirical research in the field of business-IT alignment and EAs is limited, particularly in South Africa. This paper fills this gap and provides a valuable contribution to the field of business and IT alignment as well as to the domain of EAs. The model was designed based on an evaluation of existing literature studies as well as on a survey of 30 medium to large South African organisations. The results of the survey were used to verify the model and to further elaborate on the extent of EA usage and acceptance in South African organisations.

Key words: Enterprise architecture; business and information technology alignment

Appendix E – Enterprise Systems and IEEE 2013 Conference Paper

An Analysis of the Adoption and Usage of Enterprise Architecture

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***Abstract*—A changing market demand and technological evolution has required that enterprise systems constantly be updated and reengineered. Enterprise Architectures (EAs) emerged as 'tools' to assist organisations with managing enterprise systems. The potential benefits obtained by the adoption of an EA programme has resulted in a steady increase in the interest in EAs, and in a study of EA activity worldwide, South Africa was ranked 10th. However, EA is a challenging concept and a number of heterogeneous architecture definitions, interpretations and classifications have been developed. It is imperative that an EA programme is considered not only as an issue for the Information Technology (IT) function, but also as a strategic and organisational challenge.**

Organisations embarking on an EA programme are faced with many complex decisions regarding which EA framework to select, which models and modelling notations to use, as well which technology strategies to adopt. Some organisations are embracing these programmes and are obtaining many benefits, others are faced with an abundance of challenges. This study investigates three popular EA frameworks and proposes an EA component classification map. Several medium to large South African organisations are investigated to validate and update elements of the model.

Keywords—enterprise architectures; EA frameworks; modelling.

I. INTRODUCTION

In the current industrial and economic context, enterprise systems need to be constantly reengineered to respond to changing market demand and technological evolution [1]. Enterprise Architecture (EA), as part of the larger field of enterprise systems engineering, has emerged as a 'tool' which can assist stakeholders to manage system engineering and changes. An increasing interest in EA has become evident in recent years and large enterprises as well as researchers have investigated the strategic impact of EA [2, 3, 4, 5]. In contrast to traditional architecture approaches which focus on technology architecture, software architecture or Information Systems (IS) architecture, more recent EA approaches, have more of a business-related focus rather than a pure IT focus and thereby provide greater support for aligning business and Information Technology (IT) more effectively [5, 7, 22, 33, 36, 43, 44].

In spite of the potential benefits of EA and an increase in the number of EA adoption programmes which have been reported by [3,4,6,7,8,9,10], several challenges with EA have been cited [1,2,11,12,13,14]. These problems relate to the lack of precision of methods and unwieldy methods used as well as ambiguity in terms of goals, concepts and frameworks [12]. It has become not only an IT issue, but first of all, a strategic and organisational challenge [1]. EA for some organisations is a challenging and still confusing concept. Disparate views are held on what EA entails and how it is administered [2, 11]. The field of EA is in its infancy compared to other fields, such as the construction industry where architects use standard symbols that can be recognised and understood by all members of their industry to carry out construction work [1]. In construction projects architectural methods and design have been tried and tested whereas the enterprise engineering community is much younger and has not experienced the advantage of a "time tested'' structure, but instead, many diverse EA frameworks and methodologies have been proposed [3,11].

Appendix F – Survey Cover Letter

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COVER PAGE

Nelson Mandela Metropolitan University
for tomorrow

Human Ethics reference number: H12-Sci-CS-018

Dear Sir / Madam,

I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) and am currently doing my second year of my Masters degree. The aim of this research is to investigate the extent to which Enterprise Architectures (EAs) support environmental information. In order to determine this, a study needs to be performed to identify what companies are doing in terms of sustainability reporting, environmental information management and EAs.

EA is defined as "an architecture in which the system in question is the whole enterprise, especially the business processes, technologies, and information systems of the enterprise". The four common components of EAs are: information architectures (IAs), business architectures, technology architectures and application architectures.

South African legislation for JSE listed companies requires a company to report on their impact on the environment, as part of their sustainability reports. Types of environmental information include water, energy, air emissions, material use, etc. In addition the number of non JSE-listed companies producing sustainability reports is rapidly increasing.

The information obtained from this questionnaire will be treated with strict confidentiality, and will not be used for any purpose other than for writing the research thesis for academic purposes. The information will be presented in an anonymous or aggregated fashion and no details will be provided. Your cooperation to participate in this survey is greatly appreciated.

You can indicate to me via email (anthea.connolley@nmmu.ac.za) if you would like a copy of the summarised results of this study. Thank you for your co-operation.

Yours sincerely,

Anthea Connolley

Masters student

Supervisors: Prof Andre Calitz and Dr Brenda Scholtz

Appendix G – Case Study Cover Letter

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

Nelson Mandela Metropolitan University
for tomorrow

Human Ethics reference number: H12-Sci-CS-018

Dear Sir / Madam,

I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) and am currently doing my second year of my Master's degree.

You have previously completed an Online Survey regarding my research to investigate the extent to which Enterprise Architectures (EAs) support environmental information. You are now requested to partake in a further Interview study. On acceptance to participate in the Interview study, the aim of this study is further explained. The explanation will be based on certain responses given during the Online Survey.

The aim of the Interview study is to determine how your organisation uses your EA to improve environmental sustainability information management.

The information obtained during the Interview will be treated with strict confidentiality, and will not be used for any purpose other than for writing the research thesis for academic purposes. The information will be presented in an anonymous or aggregated fashion and no details will be provided. Your cooperation to participate in this survey is greatly appreciated.

You can indicate to me via email (anthea.connolley@nmmu.ac.za) if you would like a copy of the summarised results of this study. Thank you for your co-operation.

Yours sincerely,

Anthea Connolley

Masters student

Supervisors: Prof André Calitz and Dr Brenda Scholtz

Appendix H – Organisational Background Questionnaire

Note: This is a confidential questionnaire. Your identity will not be revealed. Your willingness to participate is most appreciated. Feedback will be provided to all participants upon request. Human Ethics reference number: H12-Sci-CS-018

1. COMPANY DETAILS

1.1 *	Company/Organisation Name	

2. INDUSTRY

2.1 *	What is the primary industry of the organisation?	○ Automotive ○ Banking & Financial Services ○ Biotechnology & Pharmaceuticals ○ Chemicals ○ Construction & Engineering ○ Consulting & Business Services ○ Consumer Goods ○ Distribution ○ Electronics ○ Energy & Utilities ○ Health Care & Medical ○ Information Technology ○ Insurance ○ Logistics & Transportation ○ Manufacturing ○ Media & Entertainment ○ Metals & Natural Resources ○ Retail ○ Telecommunications ○ Other
2.2	If you have selected 'Other' in the question above, please specify here	

3. SIZE

For the organisation being described, please indicate the size and scale.

3.1 *	Number of employees	1-10 11-50 51-100 101-500 500+
3.2 *	Number of Sustainability Reporting and Environmental Management Staff	1-5 6-10 11-20 21-50 51+ None
3.3 *	Number of Enterprise Architects	1-5 6-10 11-20 21-50 51+ None

Appendix I – Enterprise Architecture Questionnaire

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Note: This is a confidential questionnaire. Your identity will not be revealed. Your willingness to participate is most appreciated. Feedback will be provided to all participants upon request. Human Ethics reference number: H12-Sci-CS-018

1. COMPANY DETAILS

1.1 *	Company/Organisation Name	

This research is being conducted in fulfilment of the requirements for the degree Magister Commercii in Computing Sciences at Nelson Mandela Metropolitan University.

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2. BIOGRAPHICAL INFORMATION

2.1	What is your name? (Optional)	
2.2 *	Gender	Male Female
2.3 *	Choose the appropriate age category	18-25 26-33 34-40 41-47 48+
2.4 *	What is your job title?	Business Process Manager Enterprise Architect Information Architect IT Manager/Director CIO Other
2.5	If you have selected 'Other' in the question above, please specify here	
2.6 *	Please list in your company who else is involved with Sustainability Reporting	

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To clarify what is meant by the terms Enterprise Architectures (EAs) and Information Architectures (IAs), the following definition will be used to describe EA: "the description of the stakeholders' mission including information, functionality, location, organisation, and performance parameters. EA also describes the plan for building a system or set of systems". Research shows that EA contains different sections and one of them is the IA. IAs describes the structure of a system and

categorise the artifacts of organisational systems. It is also referred to as the foundation of an organisation that contains all the important information. The purpose of having an IA is to improve the access, relevance and usefulness of information.

3. ENTERPRISE ARCHITECTURE (EA) PROGRAMME

It is found that an EA commonly consists of different sections including: business architecture, information architecture, application architecture and technology architecture.

3.1 *	What best describes the current state of your organisation's EA programme?	○ My organisation currently has an EA programme ○ My organisation is currently expanding our EA programme ○ My organisation had an EA programme in the past but does not have one now ○ My organisation is thinking about adopting an EA programme ○ Other
3.2	If you have selected 'Other' in the question above, please specify here	
3.3 *	How many years do/did your organisation have an EA programme for?	○ 0-5 ○ 5-10 ○ 11-16 ○ 17+
3.4 *	Which of the following sections does/did your organisation's EA programme contain?	☐ Business Architecture ☐ Information Architecture ☐ Application Architecture ☐ Technology Architecture ☐ Other
3.5	If you have selected 'Other' in the question above, please specify here	
3.6 *	Do you agree/disagree that your organisation takes into account environmental information when designing its EA?	Strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Strongly agree
3.7 *	Do you agree/disagree that your organisation takes into account environmental information when designing its IA?	Strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Strongly agree

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4. PLEASE RATE THE FOLLOWING ACCORDINGLY

Do you agree/disagree that the following are/were the objectives for your EA programme?

4.1 *	Promote common technical infrastructure	Strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Strongly agree
4.2 *	Business efficiency/transformation	Strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Strongly agree

4.3 *	Reduce operating costs	Strongly disagree	1	2	3	4	5	Strongly agree
4.4 *	Support system integration	Strongly disagree	1	2	3	4	5	Strongly agree
4.5 *	Improve technical integrity	Strongly disagree	1	2	3	4	5	Strongly agree
4.6 *	Improve enterprise decision-making	Strongly disagree	1	2	3	4	5	Strongly agree
4.7 *	Improve IT governance	Strongly disagree	1	2	3	4	5	Strongly agree
4.8 *	Improve data integrity	Strongly disagree	1	2	3	4	5	Strongly agree
4.9 *	Improve risk management	Strongly disagree	1	2	3	4	5	Strongly agree
4.10 *	Reduce technical complexity	Strongly disagree	1	2	3	4	5	Strongly agree
4.11 *	Ensure continuity of organisational knowledge	Strongly disagree	1	2	3	4	5	Strongly agree
4.12 *	Include/Improve environmental concerns	Strongly disagree	1	2	3	4	5	Strongly agree
4.13 *	Increase effectiveness of audit Compliance	Strongly disagree	1	2	3	4	5	Strongly agree
4.14 *	Support outsourcing initiatives	Strongly disagree	1	2	3	4	5	Strongly agree
4.15	Other	Strongly disagree	1	2	3	4	5	Strongly agree
4.16	If you have selected 'Other' in the question above, please specify here							

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5. PLEASE RATE THE FOLLOWING ACCORDINGLY

Do you agree/disagree that the following are types of models produced by your organisation?

5.1 *	Business architecture model	Strongly disagree	1	2	3	4	5	Strongly agree
5.2 *	Component model	Strongly disagree	1	2	3	4	5	Strongly agree
5.3 *	Deployment models	Strongly disagree	1	2	3	4	5	Strongly agree
5.4 *	Detailed enterprise data model (EDM)	Strongly disagree	1	2	3	4	5	Strongly agree

5.5 *	Enterprise business process model	Strongly disagree	1	2	3	4	5	Strongly agree
5.6 *	Enterprise use case model	Strongly disagree	1	2	3	4	5	Strongly agree
5.7 *	High-level conceptual data model	Strongly disagree	1	2	3	4	5	Strongly agree
5.8 *	Security models	Strongly disagree	1	2	3	4	5	Strongly agree
5.9	Other	Strongly disagree	1	2	3	4	5	Strongly agree
5.10	If you have selected 'Other' in the question above, please specify here							

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6. PLEASE RATE THE FOLLOWING ACCORDINGLY

Does/did your EA programme apply the following modeling notations?

6.1 *	Unified Modelling Language (UML)	Never	1	2	3	4	5	Always
6.2 *	Domain-specific modelling language	Never	1	2	3	4	5	Always
6.3 *	Business Process Modelling Notation (BPMN)	Never	1	2	3	4	5	Always
6.4 *	We have our own internal standard notations	Never	1	2	3	4	5	Always
6.5	Please specify your internal standard notations							

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7. PLEASE RATE THE FOLLOWING ACCORDINGLY

The following technology strategies are/were captured by the EA

7.1 *	Business process management (BPM)	Strongly disagree	1	2	3	4	5	Strongly agree
7.2 *	Software as a Service (SAAS)	Strongly disagree	1	2	3	4	5	Strongly agree
7.3 *	Service Oriented Architecture (SOA)	Strongly disagree	1	2	3	4	5	Strongly agree
7.4 *	Cloud Computing	Strongly disagree	1	2	3	4	5	Strongly agree

7.5 *	Components	Strongly disagree	1	2	3	4	5	Strongly agree
7.6 *	Common Frameworks	Strongly disagree	1	2	3	4	5	Strongly agree
7.7 *	Product Line Architecture	Strongly disagree	1	2	3	4	5	Strongly agree
7.8	Other	Strongly disagree	1	2	3	4	5	Strongly agree
7.9	If you have selected 'Other' in the question above, please specify here							

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8. PLEASE RATE THE FOLLOWING ACCORDINGLY

Your EA programme applies the following EA frameworks?

8.1 *	TOGAF	Strongly disagree	1	2	3	4	5	Strongly agree
8.2 *	MODAF	Strongly disagree	1	2	3	4	5	Strongly agree
8.3 *	Zachman	Strongly disagree	1	2	3	4	5	Strongly agree
8.4 *	We created our own	Strongly disagree	1	2	3	4	5	Strongly agree
8.5	Please specify the framework you've created							

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9. PLEASE RATE AND ANSWER THE FOLLOWING ACCORDINGLY

9.1 *	Your organisation has experienced benefits using your EA	Strongly disagree	1	2	3	4	5	Strongly agree
9.2 *	What are the benefits that your organisation has experienced using your EA?							

10. PLEASE RATE THE FOLLOWING ACCORDINGLY

The following has improved as a result of you EA programme

10.1 *	System integration	Strongly disagree	1	2	3	4	5	Strongly agree
10.2 *	IT governance	Strongly disagree	1	2	3	4	5	Strongly agree
10.3 *	Team follows a common technical infrastructure	Strongly disagree	1	2	3	4	5	Strongly agree
10.4 *	Business efficiency	Strongly disagree	1	2	3	4	5	Strongly agree
10.5 *	Data integrity	Strongly disagree	1	2	3	4	5	Strongly agree
10.6 *	Continuity of organisation knowledge	Strongly disagree	1	2	3	4	5	Strongly agree
10.7 *	Business governance	Strongly disagree	1	2	3	4	5	Strongly agree
10.8 *	Audit compliance	Strongly disagree	1	2	3	4	5	Strongly agree
10.9 *	Risk management	Strongly disagree	1	2	3	4	5	Strongly agree
10.10 *	Technical integrity	Strongly disagree	1	2	3	4	5	Strongly agree
10.11	Other	Strongly disagree	1	2	3	4	5	Strongly agree

11. PLEASE RATE AND ANSWER THE FOLLOWING ACCORDINGLY

11.1 *	Your organisation has experienced challenges using your EA	Strongly disagree	1	2	3	4	5	Strongly agree
11.2 *	What are the challenges that your organisation has experienced using your EA?							

Appendix J – Environmental Information Management (EIM) Questionnaire

Page No: 1

Note: This is a confidential questionnaire. Your identity will not be revealed. Your willingness to participate is most appreciated. Feedback will be provided to all participants upon request. Human Ethics reference number: H12-Sci-CS-018

1. COMPANY DETAILS

1.1 *	Company/Organisation Name	

This research is being conducted in fulfilment of the requirements for the degree Magister Commercii in Computing Sciences at Nelson Mandela Metropolitan University.

Page No: 2

2. BIOGRAPHICAL INFORMATION

2.1	What is your name? (Optional)	
2.2 *	Gender	Male Female
2.3 *	Choose the appropriate age category	18-25 26-35 36-45 46-55 56+
2.4 *	What is your job title?	Enterprise Architect Information Architect IT Manager/Director Environmental Manager Sustainability reporting Manager Eco-controller Other
2.5	If you have selected 'Other' in the question above, please specify here	

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Organisations in South Africa by law have to “apply or explain” the King 3 report. The KingIII report places great emphasis on sustainability which includes three areas (economic, environmental and social). Sustainability reporting involves the way an organisation reports on its activities and impacts relating to financial, environmental and social issues.

3. SUSTAINABILITY REPORTING (SR)

3.1 *	What best describes the current state of your organisation's SR?	○ My organisation does not report on sustainability matters ○ My organisation practices sustainability reporting internally only ○ My organisation practices sustainability reporting internally as well as provides a sustainability report to external stakeholders ○ Other
3.2	If you have selected 'Other' in the question above, please specify here	
3.3 *	Who is the target audience for your organisation's sustainability reports (SRs)?	☐ Customers ☐ Suppliers ☐ Employees ☐ NGO's ☐ International organisations/partners ☐ Government (legislation compliance) ☐ Other
3.4	If you have selected 'Other' in the question above, please specify here	
3.5 *	Who is the most important target audience for your organisation's SRs?	○ Customers ○ Employees ○ NGO's ○ International organisations/partners ○ Government (legislation compliance) ○ Other
3.6	If you have selected 'Other' in the question above, please specify here	

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4. PLEASE RATE AND ANSWER THE FOLLOWING ACCORDINGLY

Your organisation processes include the following

4.1 *	Environmental Reporting	Strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	Strongly agree

4.2 *	Social Reporting	Strongly disagree	1	2	3	4	5	Strongly agree
4.3 *	Economic Reporting	Strongly disagree	1	2	3	4	5	Strongly agree
4.4 *	Your organisation has experienced benefits with Environmental Reporting?	Strongly disagree	1	2	3	4	5	Strongly agree
4.5 *	What are the benefits that your organisation has experienced with Environmental Reporting?							
4.6 *	Your organisation has experienced challenges with Environmental Reporting?	Strongly disagree	1	2	3	4	5	Strongly agree
4.7 *	What are the challenges that your organisation has experienced with Environmental Reporting?							

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5. PLEASE RATE THE FOLLOWING ACCORDINGLY

The following standards/methods are used in your organisation

5.1 *	ISO 14001	Strongly disagree	1	2	3	4	5	Strongly agree
5.2 *	EMS	Strongly disagree	1	2	3	4	5	Strongly agree
5.3 *	GRI	Strongly disagree	1	2	3	4	5	Strongly agree
5.4	Other	Strongly disagree	1	2	3	4	5	Strongly agree
5.5	If you have selected 'Other' in the question above, please specify here							

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6. PLEASE RATE THE FOLLOWING ACCORDINGLY

Rate the following main stakeholders' concerns and challenges in the SR according to the importance in your organisation.

6.1 *	Environmental issues (e.g. water, energy, air emissions, material use)	Not important	1	2	3	4	5	Very important
6.2 *	Social issues (e.g. Human rights, Labour practices)	Not important	1	2	3	4	5	Very important

6.3 *	Economic issues (e.g. direct financial impacts on stakeholders or indirect economic impacts)	Not important	1	2	3	4	5	Very important

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7. PLEASE RATE THE FOLLOWING ACCORDINGLY

Your organisation uses these tools to help monitor and manage its SR endeavours

7.1 *	Excel/SpeadSheet	Never	1	2	3	4	5	Always
7.2 *	Sustainability reporting system (web-based or other)	Never	1	2	3	4	5	Always
7.3 *	Web-based reporting tools	Never	1	2	3	4	5	Always
7.4 *	Internal information systems	Never	1	2	3	4	5	Always
7.5	Other	Never	1	2	3	4	5	Always
7.6	If you have selected 'Other' in the question above, please specify here							
7.7	Please specify which Sustainability reporting system your organisation uses							
7.8	Please specify which Web-based reporting tools your organisation uses for SR							
7.9	Please specify which internal information systems your organisation uses for SR							

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8. PLEASE RATE THE FOLLOWING ACCORDINGLY

Your organisation has the following objectives:

8.1 *	Improve SR practices	Strongly disagree	1	2	3	4	5	Strongly agree
8.2 *	Improve dialogue with stakeholders about sustainability	Strongly disagree	1	2	3	4	5	Strongly agree
8.3 *	Improve sustainability marketing	Strongly disagree	1	2	3	4	5	Strongly agree
8.4 *	Initiate programs to eliminate hazardous substances in materials and parts purchased	Strongly disagree	1	2	3	4	5	Strongly agree

8.5 *	Increase sustainable use of natural resources (e.g. land, forests, animal population, etc.)	Strongly disagree	1	2	3	4	5	Strongly agree	
8.6	Other	Strongly disagree	1	2	3	4	5	Strongly agree	
8.7	If you have selected 'Other' in the question above, please specify here								

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The following are Key sustainability indicators that have been taken from the Global Reporting Initiative G3.1 Standard Disclosure of performance indicators. Only the Environmental indicators are listed here since this is part of the focus of this research.

9. ENVIRONMENTAL REPORTING

Please rate each of Key GRI Environmental (EN) Indicators below, according to the importance to your organisation (based on Energy Consumption and Emission as well as Water Consumption and Impact)

9.1 *	EN3 Direct energy consumption by primary energy source	Not important	1	2	3	4	5	Very important	
9.2 *	EN4 Indirect energy consumption by primary source	Not important	1	2	3	4	5	Very important	
9.3 *	EN16 Total direct and indirect greenhouse gas emissions by weight.	Not important	1	2	3	4	5	Very important	
9.4 *	EN17 Other relevant indirect greenhouse gas emissions by weight	Not important	1	2	3	4	5	Very important	
9.5 *	EN18 Initiatives to reduce greenhouse gas emissions and reductions achieved	Not important	1	2	3	4	5	Very important	
9.6 *	EN8 Total water withdrawal by source	Not important	1	2	3	4	5	Very important	
9.7 *	EN9 Water sources significantly affected by withdrawal of water	Not important	1	2	3	4	5	Very important	
9.8 *	EN10 Percentage and total volume of water recycled and reused	Not important	1	2	3	4	5	Very important	

Appendix K – Statistical Values and Calculations

Scores for Case Study Participants

Ranking Categories

		Ranking Category-EA Questionnaire			Ranking Category-EIM Questionnaire			Ranking Category-EA and EIM Questionnaires Combined		
Company Number	Type of Industry	Score	Rank	**Cat.**	Score	Rank	**Cat.**	Score	Rank	**Cat.**
C07	2	9.34	1	V.Well	8.97	1	V.Well	9.15	1	V.Well
C28	3	8.73	2	V.Well	8.21	5	V.Well	8.47	2	V.Well
C20	3	7.63	9	Well	8.78	3	V.Well	8.20	3	V.Well
C14	3	8.16	3	V.Well	7.82	8	Well	7.99	4	Well
C13	3	7.80	4	Well	7.91	6	Well	7.85	5	Well
C09	2	7.49	10	Well	7.72	9	Well	7.61	6	Well
C22	3	7.66	8	Well	7.53	11	Well	7.60	7	Well
C27	3	7.75	6	Well	7.12	14	Well	7.43	8	Well
C18	3	5.62	25	Fair	8.84	2	V.Well	7.23	9	Well
C30	2	6.09	18	Well	8.30	4	V.Well	7.19	10	Well
C03	2	6.78	14	Well	7.38	12	Well	7.08	11	Well
C10	3	7.76	5	Well	6.22	18	Well	6.99	12	Well
C17	2	7.47	12	Well	6.46	15	Well	6.96	13	Well
C15	2	5.63	24	Fair	7.84	7	Well	6.73	14	Well
C19	1	5.96	20	Fair	7.33	13	Well	6.65	15	Well
C16	2	5.32	26	Fair	7.65	10	Well	6.48	16	Well
C31	3	5.92	21	Fair	6.45	16	Well	6.18	17	Well
C24	1	6.63	16	Well	5.27	22	Fair	5.95	18	Fair
C21	1	6.62	17	Well	5.23	23	Fair	5.93	19	Fair
C26	1	7.10	13	Well	4.58	25	Fair	5.84	20	Fair
C02	3	5.69	22	Fair	5.88	19	Fair	5.78	21	Fair
C29	1	5.69	23	Fair	5.63	21	Fair	5.66	22	Fair
C11	1	7.72	7	Well	3.55	28	Poor	5.64	23	Fair
C25	2	6.04	19	Well	5.19	24	Fair	5.62	24	Fair
C08	3	6.68	15	Well	4.27	26	Fair	5.47	25	Fair
C04	3	7.47	11	Well	3.24	29	Poor	5.36	26	Fair
C06	3	3.47	30	Poor	5.78	20	Fair	4.62	27	Fair
C01	2	5.29	27	Fair	3.23	30	Poor	4.26	28	Fair
C05	3	4.25	28	Fair	3.84	27	Poor	4.04	29	Fair
C23	3	1.00	31	V.Poor	6.30	17	Well	3.65	30	Poor
C12	3	3.59	29	Poor	2.30	31	Poor	2.94	31	Poor

Table x: Descriptive statistics: RC.EA.3.1&3 to RC.EA&EIM (n = 31)

Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum

RC.EA.04	7.24	2.25	0.00	6.25	7.88	8.85	10.00
RC.EA.3.4	7.03	2.24	2.00	6.00	8.00	8.00	10.00
RC.EA.05	6.55	2.51	0.00	5.00	6.88	8.13	10.00
RC.EA.07	6.29	1.68	1.52	5.27	6.20	7.55	8.80
RC.EA.3.1&3	5.65	2.21	0.00	4.00	5.67	7.33	9.00
RC.EA.06	5.63	2.27	0.00	5.00	5.63	6.88	10.00
RC.EA	6.40	1.71	1.00	5.66	6.63	7.65	9.34
RC.EIM.3.1	7.90	2.82	0.00	5.00	10.00	10.00	10.00
RC.EIM.6	7.74	1.79	4.17	6.25	8.33	9.17	10.00
RC.EIM.4	6.89	1.64	3.00	5.75	7.00	8.00	9.50
RC.EIM.8	6.18	2.61	1.50	3.50	7.00	8.25	10.00
RC.EIM.7	5.71	2.09	1.25	4.06	6.25	7.19	10.00
RC.EIM.3.3	5.65	3.26	1.25	1.88	6.25	8.75	8.75
RC.EIM.9	5.23	3.01	0.00	3.59	5.00	7.81	10.00
RC.EIM.5	4.97	3.05	0.00	2.50	5.83	7.08	10.00
RC.EIM	6.28	1.85	2.30	5.21	6.45	7.77	8.97
RC.EA&EIM	6.34	1.46	2.94	5.63	6.48	7.33	9.15

Statistical Difference Calculations

EA Questionnaire Sections

RANKING STATS - Descending											
Objectives Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
Improve risk management	Improve IT Governance	1	31	0.03	0.84	0.21	30	0.416	-	Not	-
Improve risk management	Support system integration	1	31	0.06	1	0.36	30	0.361	-	Not	-
Improve risk management	Improve enterprise decision-making	1	31	0.06	1.03	0.35	30	0.365	-	Not	-
Improve risk management	Business efficiency/transformation	1	31	0.1	0.79	0.68	30	0.25	-	Not	-
Improve risk management	Promote Technical Infrastructure	1	31	0.13	1.28	0.56	30	0.29	-	Not	-
Improve risk management	Reduce operating costs	1	31	0.13	0.85	0.85	30	0.201	-	Not	-
Improve risk management	Improve technical integrity	1	31	0.16	1.07	0.84	30	0.203	-	Not	-
Improve risk management	Increase effectiveness of audit Compliance	1	31	0.19	0.91	1.18	30	0.123	0.21	Not	-
Improve risk management	Improve data integrity	1	31	0.23	0.92	1.37	30	0.091	0.25	Not	-
Improve risk management	Reduce technical complexity	1	31	0.35	0.88	2.25	30	0.016	0.4	Not	-

Improve risk management	Ensure continuity of organisational knowledge	1	31	0.39	0.84	2.55	30	0.008	0.46	Not	-
Improve risk management	Support outsourcing initiatives	1	31	0.77	1.56	2.76	30	0.005	0.49	Not	-
Improve risk management	Include/Improve environmental concerns	2	31	1	1.13	4.95	30	0	0.89	Yes	Yes

RANKING STATS - Ascending											
Objectives Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Include/Improve environmental concerns	Support outsourcing initiatives	1	31	-0.23	1.54	0.81	30	0.211	-	Not	-
Include/Improve environmental concerns	Ensure continuity of organisational knowledge	2	31	-0.61	1.02	3.34	30	0.001	0.6	Yes	Yes
Ensure continuity of organisational knowledge	Reduce technical complexity	2	31	-0.03	0.87	0.21	30	0.419	-	Not	-
Ensure continuity of organisational knowledge	Improve data integrity	2	31	-0.16	0.93	0.96	30	0.172	0.17	Not	-
Ensure continuity of organisational knowledge	Increase effectiveness of audit Compliance	2	31	-0.19	0.91	1.18	30	0.123	0.21	Not	-
Ensure continuity of organisational knowledge	Improve technical integrity	2	31	-0.23	0.92	1.37	30	0.091	0.25	Not	-
Ensure continuity of organisational knowledge	Reduce operating costs	2	31	-0.26	1.15	1.25	30	0.111	0.22	Not	-
Ensure continuity of organisational knowledge	Promote Technical Infrastructure	2	31	-0.26	1.12	1.28	30	0.106	0.23	Not	-
Ensure continuity of organisational knowledge	Business efficiency/ transformation	2	31	-0.29	0.74	2.19	30	0.018	0.39	Not	-

Ensure continuity of organisational knowledge	Improve enterprise decision-making	3	31	-0.32	0.65	2.75	30	0.005	0.49	Yes	Yes
Improve enterprise decision-making	Support system integration	3	31	0	0.93	0	30	0.5	-	Not	-
Improve enterprise decision-making	Improve IT Governance	3	31	-0.03	0.98	0.18	30	0.428	-	Not	-
Improve enterprise decision-making	Improve risk management	3	31	-0.06	1.03	0.35	30	0.365	-	Not	-

RANKING STATS - Descending											
Models Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Business architecture model	Security models	1	31	0	1.24	0	30	0.5	-	Not	-
Business architecture model	Enterprise business process model	1	31	0.1	0.87	0.62	30	0.27	-	Not	-
Business architecture model	High-level conceptual data model	1	31	0.26	1.18	1.22	30	0.117	0.22	Not	-
Business architecture model	Component model	1	31	0.32	1.28	1.41	30	0.085	0.25	Not	-
Business architecture model	Deployment models	1	31	0.35	1.36	1.46	30	0.078	0.26	Not	-
Business architecture model	Detailed enterprise data model (EDM)	1	31	0.45	1.43	1.75	30	0.045	0.31	Not	-
Business architecture model	Enterprise use case model	2	31	0.77	1.28	3.36	30	0.001	0.6	Yes	Yes

RANKING STATS - Ascending											
Models Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Enterprise use case model	Detailed enterprise data model (EDM)	2	31	-0.32	1.01	1.77	30	0.043	0.32	Yes	Yes
Detailed enterprise data model (EDM)	Deployment models	2	31	-0.1	1.27	0.42	30	0.338	-	Not	-
Detailed enterprise data model (EDM)	Component model	2	31	-0.13	1.26	0.57	30	0.286	-	Not	-
Detailed enterprise data model (EDM)	High-level conceptual data model	2	31	-0.19	1.01	1.06	30	0.148	0.19	Not	-
Detailed enterprise data model (EDM)	Enterprise business process model	2	31	-0.35	0.95	2.08	30	0.023	0.37	Not	-
Detailed enterprise data model (EDM)	Security models	2	31	-0.45	1.18	2.13	30	0.021	0.38	Not	-
Detailed enterprise data model (EDM)	Business architecture model	2	31	-0.45	1.43	1.75	30	0.045	0.31	Not	-

RANKING STATS - Descending											
Modelling Notations Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Business Process Modelling Notation (BPMN	Industry specific modelling language	1	31	0.06	1.34	0.27	30	0.395	-	Not	-
Business Process Modelling Notation (BPMN	Unified Modelling Language (UML)	1	31	0.26	1	1.44	30	0.08	0.26	Not	-
Business Process Modelling Notation (BPMN	We have our own internal standard notations	1	31	0.74	2.03	2.03	30	0.026	0.37	Not	-

RANKING STATS - Ascending											
Modelling Notations Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
We have our own internal standard notations	Unified Modelling Language (UML)	1	31	-0.48	2.2	1.22	30	0.116	0.22	Not	-
We have our own internal standard notations	Industry specific modelling language	1	31	-0.68	1.87	2.02	30	0.026	0.36	Not	-
We have our own internal standard notations	Business Process Modelling Notation (BPMN)	1	31	-0.74	2.03	2.03	30	0.026	0.37	Not	-

RANKING STATS - Descending											
Technologies Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Business process management (BPM)	Components	1	31	0.35	1.2	1.65	30	0.055	0.3	Not	-
Business process management (BPM)	Common Frameworks	2	31	0.39	1.02	2.11	30	0.022	0.38	Yes	Yes
Common Frameworks	Service Oriented Architecture (SOA)	2	31	0.1	1.22	0.44	30	0.331	-	Not	-
Common Frameworks	Cloud Computing	2	31	0.29	1.19	1.36	30	0.092	0.24	Not	-
Common Frameworks	Product Line Architecture	2	31	0.32	1.01	1.77	30	0.043	0.32	Not	-
Common Frameworks	Software as a Service (SAAS)	2	31	0.52	1.23	2.33	30	0.013	0.42	Not	-

RANKING STATS - Ascending											
Technologies Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
Software as a Service (SAAS)	Product Line Architecture	1	31	-0.19	1.28	0.84	30	0.203	-	Not	-
Software as a Service (SAAS)	Cloud Computing	1	31	-0.23	0.92	1.37	30	0.091	0.25	Not	-
Software as a Service (SAAS)	Service Oriented Architecture (SOA)	2	31	-0.42	0.99	2.35	30	0.013	0.42	Yes	Yes
Service Oriented Architecture (SOA)	Common Frameworks	2	31	-0.1	1.22	0.44	30	0.331	-	Not	-
Service Oriented Architecture (SOA)	Components	2	31	-0.13	1.28	0.56	30	0.29	-	Not	-
Service Oriented Architecture (SOA)	Business process management (BPM)	2	31	-0.48	1.5	1.79	30	0.042	0.32	Not	-

RANKING STATS - Descending											
Frameworks Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
TOGAF	Zachman	2	31	0.32	0.83	2.16	30	0.02	0.39	Yes	Yes
Zachman	We created our own	2	31	0.13	2.29	0.31	30	0.378	-	Not	-
Zachman	MODAF	3	31	1.58	1.48	5.95	30	0	1.07	Yes	Yes

RANKING STATS - Ascending											
Frameworks Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
TOGAF	We created our own	2	31	-1.45	1.82	4.43	30	0	0.8	Yes	Yes
MODAF	Zachman	2	31	-0.13	2.29	0.31	30	0.378	-	Not	-

MODAF	TOGAF	2	31	-0.45	2.29	1.1	30	0.141	0.2	Not	-

RANKING STATS - Descending											
Benefits Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
System integration	IT governance	1	31	0.13	0.76	0.94	30	0.177	0.17	Not	-
System integration	Team follows a common technical infrastructure	1	31	0.16	0.9	1	30	0.163	0.18	Not	-
System integration	Business efficiency	1	31	0.19	1.08	1	30	0.163	0.18	Not	-
System integration	Audit compliance	1	31	0.19	1.14	0.95	30	0.176	0.17	Not	-
System integration	Risk management	1	31	0.19	0.98	1.1	30	0.14	0.2	Not	-
System integration	Technical integrity	1	31	0.19	0.65	1.65	30	0.055	0.3	Not	-
System integration	Data integrity	1	31	0.42	0.92	2.53	30	0.008	0.45	Not	-
System integration	Continuity of organisation knowledge	1	31	0.48	1.06	2.54	30	0.008	0.46	Not	-
System integration	Business governance	2	31	0.65	1.08	3.32	30	0.001	0.6	Yes	Yes

RANKING STATS - Ascending											
Benefits Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Business governance	Continuity of organisation knowledge	1	31	-0.16	0.73	1.22	30	0.116	0.22	Not	-
Business governance	Data integrity	1	31	-0.23	1.23	1.02	30	0.158	0.18	Not	-
Business governance	Technical integrity	2	31	-0.45	0.99	2.53	30	0.008	0.45	Yes	Yes
Technical integrity	Risk management	2	31	0	0.77	0	30	0.5	-	Not	-
Technical integrity	Audit compliance	2	31	0	0.89	0	30	0.5	-	Not	-
Technical integrity	Business efficiency	2	31	0	1.15	0	30	0.5	-	Not	-

Technical integrity	Team follows a common technical infrastructure	2	31	-0.03	0.84	0.21	30	0.416	-	Not	-
Technical integrity	IT governance	2	31	-0.06	0.77	0.47	30	0.322	-	Not	-
Technical integrity	System integration	2	31	-0.19	0.65	1.65	30	0.055	0.3	Not	-

EIM Questionnaire Sections

RANKING STATS - Descending											
Organisational Processes Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Economic Reporting	Social Reporting	2	31	0.65	0.98	3.65	30	0	0.66	Yes	Yes
Social Reporting	Environmental Reporting	2	31	0.42	1.23	1.89	30	0.034	0.34	Not	-
Social Reporting	Your organisation has experienced benefits with Environmental Reporting?	3	31	0.77	1.15	3.76	30	0	0.68	Yes	Yes
Economic Reporting	Your organisation has experienced challenges with Environmental Reporting	3	31	0.06	1.98	0.18	30	0.429	-	Not	-

RANKING STATS - Ascending											
Organisational Processes Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Your organisation has experienced challenges with Environmental Reporting	Your organisation has experienced benefits with Environmental Reporting	1	31	-0.06	1.98	0.18	30	0.429	-	Not	-
Your organisation has experienced challenges with Environmental Reporting	Environmental Reporting	1	31	-0.42	2.03	1.15	30	0.13	0.21	Not	-

Your organisation has experienced challenges with Environmental Reporting	Social Reporting	2	31	-0.84	1.29	3.61	30	0.001	0.65	Yes	Yes
Social Reporting	Economic Reporting	3	31	-0.65	0.98	3.65	30	0	0.66	Yes	Yes

RANKING STATS - Descending											
Standards Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
ISO 14001	GRI	1	31	0.39	1.54	1.4	30	0.086	0.25	Not	-
ISO 14001	EMS	2	31	0.42	1.09	2.14	30	0.02	0.39	Yes	Yes

RANKING STATS - Ascending											
Standards Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
EMS	GRI	1	31	-0.03	1.25	0.14	30	0.443	-	Not	-
EMS	ISO 14001	2	31	-0.42	1.09	2.14	30	0.02	0.39	Yes	Yes

RANKING STATS - Descending											
Stakeholder Concerns Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Environmental issues (e.g. water, energy, air emissions, material use)	Economic issues (e.g. direct financial impacts on stakeholders or indirect economic impacts)	1	31	0.39	1.54	1.4	30	0.086	0.25	Not	-
Environmental issues (e.g. water, energy, air emissions, material use)	Social issues (e.g. Human rights, Labour practices)	2	31	0.42	1.09	2.14	30	0.02	0.39	Yes	Yes

RANKING STATS - Descending											
Tools and Technologies Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Excel	Internal information systems	1	31	0.26	1.48	0.97	30	0.17	0.17	Not	-
Excel	Web-based reporting tools	2	31	0.87	1.96	2.47	30	0.01	0.44	Yes	Yes
Web-based reporting tools	Sustainability reporting system (web-based or other)	2	31	0.1	0.87	0.62	30	0.27	-	Not	-

RANKING STATS - Ascending											
Tools and Technologies Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Sustainability reporting system (web-based or other)	Web-based reporting tools	1	31	-0.1	0.87	0.62	30	0.27	-	Not	-
Sustainability reporting system (web-based or other)	Internal information systems	2	31	-0.71	1.64	2.41	30	0.011	0.43	Yes	Yes
Internal information systems	Excel	2	31	-0.26	1.48	0.97	30	0.17	0.17	Not	-

RANKING STATS - Descending											
Objectives Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**

Improve Sustainability Reporting practices	Improve dialogue with stakeholders about sustainability	1	31	0.03	0.66	0.27	30	0.393	-	Not	-
Improve Sustainability Reporting practices	Improve sustainability marketing	1	31	0.06	0.85	0.42	30	0.338	-	Not	-
Improve Sustainability Reporting practices	Increase sustainable use of natural resources	1	31	0.13	0.99	0.72	30	0.237	-	Not	-
Improve Sustainability Reporting practices	Initiate programs to eliminate hazardous substances in materials and parts purchased	1	31	0.32	1.11	1.62	30	0.058	0.29	Not	-

RANKING STATS - Ascending											
Objectives Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Initiate programs to eliminate hazardous substances in materials and parts purchased	Increase sustainable use of natural resources	1	31	-0.19	0.79	1.36	30	0.092	0.24	Not	-
Initiate programs to eliminate hazardous substances in materials and parts purchased	Improve sustainability marketing	1	31	-0.26	0.89	1.61	30	0.059	0.29	Not	-
Initiate programs to eliminate hazardous substances in materials and parts purchased	Improve dialogue with stakeholders about sustainability	1	31	-0.29	0.97	1.66	30	0.053	0.3	Not	-

Initiate programs to eliminate hazardous substances in materials and parts purchased	Improve Sustainability Reporting practices	1	31	-0.32	1.11	1.62	30	0.058	0.29	Not	-

RANKING STATS - Descending											
EN Indicators Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
EN3	EN18	1	31	0.23	0.92	1.37	30	0.091	0.25	Not	-
EN3	EN16	2	31	0.48	1.15	2.34	30	0.013	0.42	Yes	Yes
EN16	EN4	2	31	0.03	1.33	0.14	30	0.447	-	Not	-
EN16	EN8	2	31	0.03	1.02	0.18	30	0.43	-	Not	-
EN16	EN17	2	31	0.19	0.7	1.53	30	0.068	0.28	Not	-
EN16	EN10	2	31	0.19	1.22	0.88	30	0.193	0.16	Not	-
EN16	EN9	2	31	0.32	1.11	1.62	30	0.058	0.29	Not	-

RANKING STATS - Ascending											
EN Indicators Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
EN9	EN10	1	31	-0.13	0.67	1.07	30	0.146	0.19	Not	-
EN9	EN17	1	31	-0.13	1.09	0.66	30	0.257	-	Not	-
EN9	EN8	2	31	-0.29	0.59	2.75	30	0.005	0.49	Yes	Yes
EN8	EN4	2	31	0	1.44	0	30	0.5	-	Not	-
EN8	EN16	2	31	-0.03	1.02	0.18	30	0.43	-	Not	-
EN8	EN18	2	31	-0.29	1.22	1.33	30	0.097	0.24	Not	-
EN8	EN3	2	31	-0.52	1.29	2.23	30	0.017	0.4	Not	-

Questionnaire Sections Combined

RANKING STATS - Descending											
EA Questionnaire sections Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Objectives	EA Components	1	31	0.21	2	0.58	30	0.284	-	Not	-
Objectives	Models	2	31	0.69	1.37	2.78	30	0.005	0.5	Yes	Yes
Models	Technologies	2	31	0.26	1.56	0.92	30	0.182	0.17	Not	-
Models	Status and number of years of EA programme	2	31	0.9	2.7	1.86	30	0.036	0.33	Not	-
Models	Modelling Notations	3	31	0.93	2.12	2.43	30	0.011	0.44	Yes	Yes

RANKING STATS - Ascending											
EA Questionnaire sections Compared			**Difference**	**Inference**	**Significance**						
1	**2**	**Rank**	**n**	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**	**Statistical**	**Practical**
Modelling Notations	Status and number of years of EA programme	1	31	-0.03	2.49	0.06	30	0.477	-	Not	-
Modelling Notations	Technologies	2	31	-0.67	1.68	2.22	30	0.017	0.4	Yes	Yes
Technologies	Models	2	31	-0.26	1.56	0.92	30	0.182	0.17	Not	-
Technologies	EA Components	3	31	-0.74	1.75	2.35	30	0.013	0.42	Yes	Yes
EA Components	Objectives	3	31	-0.21	2	0.58	30	0.284	-	Not	-

RANKING STATS - Descending											
EIM Questionnaire sections Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
Standards	Environmental (EN) Indicators	1	31	0.16	2.66	0.34	30	0.369	-	Not	-
Standards	Target audience for sustainability reports	2	31	1.02	2.57	2.2	30	0.018	0.39	Yes	Yes
Standards	Tools and technologies	2	31	0.71	2.51	1.58	30	0.063	0.28	Not	-
Standards	Objectives	3	31	1.18	1.91	3.45	30	0.001	0.62	Yes	Yes
Objectives	Organisational processes	3	31	0.06	3.02	0.11	30	0.456	-	Not	-
Objectives	Stakeholder concerns	3	31	0.47	2.9	0.91	30	0.185	0.16	Not	-
Stakeholder concerns	Status of sustainability reporting	3	31	0.73	2.39	1.71	30	0.049	0.31	Not	-

RANKING STATS - Ascending											
EIM Questionnaire sections Compared			Difference	Inference	Significance						
1	2	Rank	n	Mean	S.D	t-value	d.f.	p-value	Cohen's d	Statistical	Practical
Standards	Environmental (EN) Indicators	1	31	-0.26	2.45	0.59	30	0.281	-	Not	-
Standards	Target audience for sustainability reports	1	31	-0.67	3.48	1.07	30	0.146	0.19	Not	-
Standards	Tools and technologies	1	31	-0.73	2.39	1.71	30	0.049	0.31	Not	-
Standards	Objectives	2	31	-1.2	2.54	2.64	30	0.007	0.47	Yes	Yes
Objectives	Organisational processes	2	31	-0.71	2.51	1.58	30	0.063	0.28	Not	-
Objectives	Stakeholder concerns	3	31	-1.56	2.07	4.22	30	0	0.76	Yes	Yes
Objectives	Status of sustainability reporting	3	31	-0.16	2.66	0.34	30	0.369	-	Not	-