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A Framework for Sustainability Decision Making System: A Proposal and an Implementation

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Abstract. Sustainability is a commitment to a new way of commissioning business activities that addresses balanced prosperity of social, economic and environmental dimensions of businesses. A sustainable business model is a roadmap for achieving sustainability and deals with the issues and dynamic relationships of sustainable dimensions of the businesses. A decision-making system that purports to support this sustainability commitment should facilitate development of sustainable business strategies, and translation of existing business operations into sustainable business processes. The system should also enable us capturing and managing sustainability related data for supporting the strategy development processes, business process reengineering processes and sustainability reporting processes. To achieve this goal we need a sustainable modelling and reporting framework that encapsulates different modelling processes e.g. decision support modelling, systems dynamics modelling, scenario modelling, simulation modelling, business process modelling, data modelling, and information modelling within a single framework. However, currently available sustainability modelling and reporting frameworks are neither integrated nor exhaustively backed by tools and technologies to support the sustainable business requirements; they also do not support the complete life cycle of a business transformation process. Therefore, businesses are facing increasing difficulty to develop, integrate and apply sustainable strategies and operations into their core business systems. This paper proposes a generic domain independent sustainability modelling and reporting framework that integrates various modelling processes for developing sustainable business models and sustainability reports. The framework encapsulates the sustainability models, modelling and reporting processes and aligns with the sustainable business framework.

1   Introduction

Sustainability is a concept and strategy for integrating and balancing three bottom lines (TBL) namely, economic, environmental and social dimensions [1] into decision-making [2] and sustainable development is a process of achieving sustainability. It is about maintaining intergenerational equity [3], creating minimum impact on the materials and maximum benefit for societies, and making positive impact on communities and societies without a long-term negative impact on the world's ecological systems [4],[5]. It is also

referred to as corporate social responsibility (CSR), Corporate Citizenship [6] and performance on TBL indicators [7], [8].

Sustainable business strategies and processes are roadmaps to achieve sustainability and it is about understanding and considering the positive and negative impacts [9] and minimising the risk of unintended consequences [10] across sustainability dimensions. It requires a wide spread transformational change in business organisations [11] to include both nature and society in the formulation, implementation and evaluation of sustainable business strategies. It also requires a systems thinking approach for transforming the planning processes. A sustainable business development approach reflects good policy development, which involves identifying the problem, assessing options for addressing the problem, considering inter-connectedness issues, and taking account of long-term pros and cons. These themes are inter-woven through the policy principles and the specific programmes of action.

Existing frameworks and systems developed for sustainability purposes are neither integrated nor coherent and do not address the entire spectrum of sustainability requirements. For example, an economic modelling and reporting system does not properly realise the social and environmental aspects and vice versa. On the other hand, sustainable business strategies drive the transformation of existing business models into sustainable business models. Sustainability indicators force changes in processes, events, states, and activities of an organisation over time. The relationship between the events, states and activities of the businesses that are affected by sustainability indicators need to be modelled for developing sustainable strategies. The modelling processes need to identify and organise useful sustainability indicators and analyse their influence on organisational goals. Many institutions are unable to adopt sustainable strategies due to lack of proper identification of sustainability indicators, lack of sufficient information, and finally lack of a modelling environment that allows one to model societal, environmental, and economic factors in an integrated fashion.

Sustainability related bodies e.g. GRI [1], NZBCSD [12] and related research centres have suggested a good number of sustainability reporting frameworks. The GRI [1] framework is a widely accepted framework that specifies reporting principles and outlines diverse indicators for each sustainability bottom line. Practicing organisations such as Shell [13] and Landcare [14] have also incorporated many other criteria.

ISO [15], Dow Jones Sustainability Indexes [16] and Baldrige National Quality Program [4] outline frameworks for evaluation and assessment of sustainability statuses, but they do not provide tools for modelling and reporting against the sustainability dimensions. EnviroMark® is a certification tool [17] that supports organisations for assessing their own operations and supply chain, health, safety and environmental performance. The Ministry of Fisheries and Environment of the New Zealand government has provided an ecological footprint calculator [8] for assessing impact on the environment. The World Conservation Union has developed quantitative tools such as the *Barometer of Sustainability* [18] and the *Participatory and Reflective Analytical Mapping for Sustainability* [19] for assessing progress towards sustainable development.

All these assessment and evaluation frameworks and tools support only a small fraction of the needs of making businesses sustainable. They have not properly addressed strategic decision-making aspects for sustainable development. Shrivastava [20] observes that a move towards 'eco-centered' strategic management requires several key shifts in the values of a business organisation. The Natural Step (TNS) is a framework of strategic planning that focuses on a long-term vision for aligning businesses with the principles of

sustainability [21]. The TNS Framework offers a rigorous view of planetary sustainability [22]. TNS can be used in conjunction with an Environmental Management framework such as ISO14001 prescribed in [15]. Nevertheless, information systems provide little support for the TNS framework. Global Environmental Management Initiative provides a SD Planner[TM] tool [23] for sustainable development planning which may be used for screening, evaluation, goal setting, gap analysis and action planning. The existing frameworks, architectures and systems that target sustainability issues of businesses can broadly be divided into the following three categories:

1. Frameworks that focuses on business issues and possess a little support from information systems (IS)
2. Frameworks that supports both the business and IS issues
3. Frameworks that supports generic information systems but hardly support sustainable business issues

Each of these categories may have targeted any or a combination of the frameworks for analysis, evaluation, modelling, and reporting. However, these frameworks, systems, practices and strategies could not address the sustainability requirements separately but a framework that integrates them can effectively respond to sustainable business needs. In this research, we have investigated and taken into consideration the sustainability related business and IS frameworks that explicitly or implicitly address any of the analysis, evaluation, modelling and reporting issues. We then propose a framework on what to do and how to transform an existing business into a sustainable business and how to extend generic IS frameworks for using the same in the context of sustainable businesses.

In this process we synthesise concepts from four different paradigms namely, sustainable business strategies and processes, current practice of sustainability modelling and reporting (SMR), existing frameworks, and information systems modelling and reporting strategies to develop the SMR framework. Figure 1 shows the inter-relationships (dotted lines) of these four paradigms and their contribution (bold lines) towards the SMR framework.

This paper describes an approach to design, development and implementation of the SMR framework that supports modelling dynamic business processes for capturing sustainable business strategies and also supports capturing data for reporting business performance on sustainability measures. The SMR framework encapsulates the dynamic relationships among the sustainability dimensions and integrates them into operational and decision making processes. This research also designs, develops and implements a generic architecture in line with the SMR framework that is flexible and customisable to suit the requirements of a business entity. A prototype is being
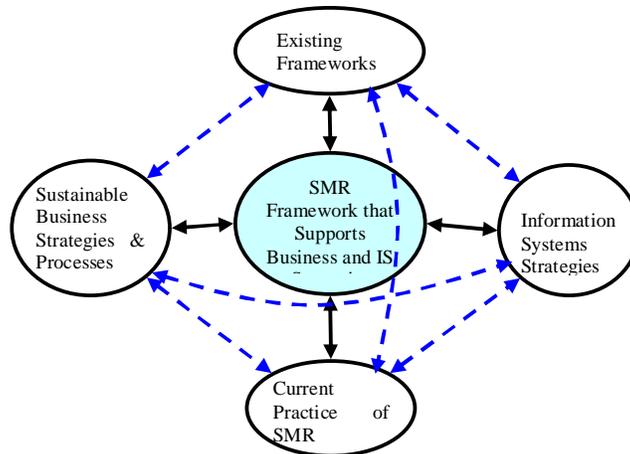

Figure 1: Research boundary

developed based on the framework and architecture. The system will be implemented and tested using different business scenarios.

2   Research Methodology

The research problem derives from the business and information systems strategies [24] and enables the business strategy and organisational infrastructure [25]. This research uses a multi-methodological research approach adopted from [26] for system sciences as shown in Figure 2. The adopted research methodology also conforms to the design science research framework proposed by Hevner et al. [27]. This research framework is comprised of the following interrelated research methodologies.

Observation – In this phase, we review currently available frameworks, information systems, business systems, processes, practices, TBL reports and reporting systems of different organisations. We also review several business cases that have already applied sustainability concepts. This leads us to define the research problem and to develop an initial conceptual framework for modelling and reporting. We also propose conceptual sustainability models as well as sustainability modelling and reporting processes. Observation continues during the next phases as well. However extensive observation will be conducted again during testing of the models, SMR framework and the prototype. Observation facilitates the formation and refinement of the SMR framework, sustainability models, modelling and reporting processes.

Theory Building – In this phase, we shall propose a generic conceptual SMR framework, sustainability models, sustainability modelling and reporting processes. Initially, theory building process depends on the outcome of the observation phase, which in turn is used to develop a system or to conduct more observations.

System Development –

Figure 2: SMR System Development Approach (Adapted from Proof of Concept Research Methodology in Information Systems Research [26])

After framing the preliminary conceptual SMR framework, models, modelling and reporting processes, we shall develop an initial prototype. This system development phase includes analysis and detailed design of models, modelling and reporting processes, and the SMR framework; it also includes construction of the system architecture, prototype development, and technology transfer. The SMR system will be used as a proof-of-concept to demonstrate feasibility of the theory and the framework.

The system will be reviewed and evaluated as prescribed in design science research framework in information systems research [27] and the findings will help better
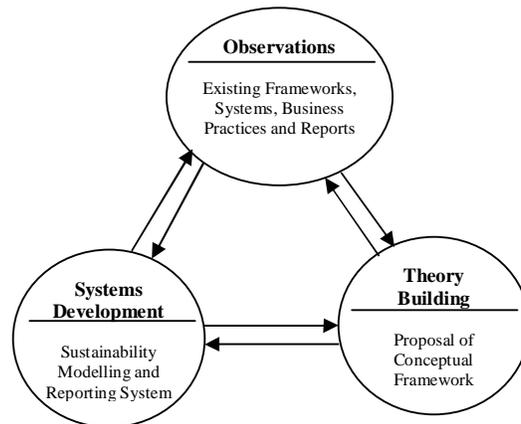
understanding of the problem which subsequently will help to improve both the quality of the artefact and the design process. The iteration of observation, theory building, and system development phase will continue until an acceptable SMR framework, sustainability models, modelling and reporting processes are developed. The observation, theory building and system development phases are iterative and the final theory of the SMR framework will be finalised after making several iterations.

3   Key Issues of Sustainability Modelling and Reporting

3.1 Issues of Sustainability Model

A comprehensive representation of a business is needed to understand its dynamic behaviour, processes, resources, internal and external stakeholders, and the constraints it must work within, and its relationship with the environment in which it operates. Models help us to manage complexity and to make substantiated decisions based on the well-understood and explicitly formulated essentials of the modelled situation [28]. Business modelling by processes facilitates developing business strategy, conducting business operations and designing information systems aligned with business organization and procedures [29]. It is easy to breakdown the complex business system into manageable simpler parts for modelling [30], but modelling in isolation is not sufficient; it is the relationship and interaction between the parts that are important. A sustainability model is an integrated model of the environmental, social and economic dimensions of businesses that help us to understand the complexities and impacts of sustainability issues. However, modelling these sustainability dimensions is not simple, as they do not have equal weight in the decision-making and operational processes. Modelling each dimension separately does not properly address sustainable development issues as they are interrelated and any change in one dimension influences the other two dimensions as illustrated in Figure 3.
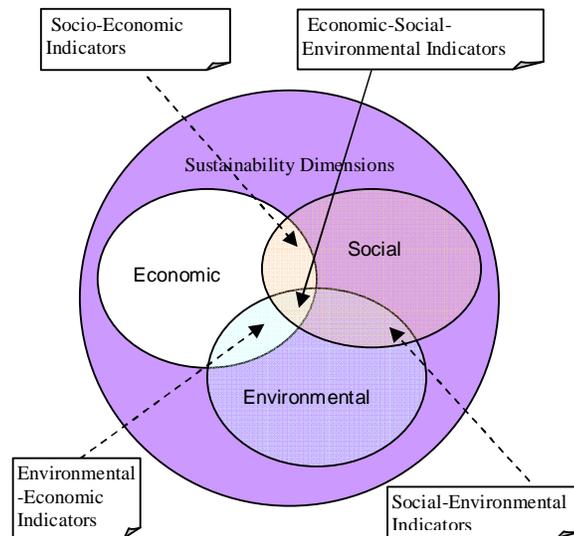

Figure 3: Inter-relationship among the sustainability dimensions of the businesses

Each dimension is again comprised of many sustainability indicators and an indicator may belong to one or more dimensions. Therefore we need to model sustainable and unsustainable patterns of behaviour for developing sustainable strategies [31], [32] by

using a generally accepted modelling principle to ensure the generalised character and reusability of the models in different businesses. Sustainability models should help in identifying a win-win-win strategy for the sustainability dimensions.

3.2 Issues of Sustainability Modelling and Reporting Processes

Very often a business starts the sustainability journey, for developing and integrating sustainable strategies for delivering balanced economic, environmental and social performance, by committing to produce a sustainability report. Sustainability reporting processes and sustainable business processes are inter-related [12] as the reporting processes are to be supported by the modelling processes and vice versa as shown in Figure 4. These reporting and modelling processes includes many others sub-processes. They are inter-linked and depend on the sustainable business strategies and vice-versa. Therefore, integration of

Harmonizing reporting processes to business processes

Harmonising business processes to reporting processes

Figure 4: Inter-relationship of sustainability modelling and reporting

sustainable development issues into mainstream business processes is a big challenge [33]. Developing and integrating sustainable business processes is a cyclic and an iterative process of commitment to the sustainability journey, identification of sustainability requirements, setting the scene for future business management, development of sustainable business models and other related models, development of sustainable business strategies, and alignment of the business processes with the new strategies. Figure 5 shows a simplified illustration of the above mentioned 6 steps. Many of these sub-processes also contain several layers of cyclic sub-processes.

The sustainable business development approach begins with developing sustainable business strategies and applying those strategies to tactical decision making and operational processes which in turn requires reorganisation and re-design of business processes. WBCSD [33] suggests three base points to the strategic planning process i.e. identifying top priorities related to sustainable development, making strategies operational, managing risk and business opportunities. This reorganisation and redesign can be achieved through comprehensive modelling of the business using critical success factors and key performance indicators. Existing enterprise systems may not capture the data required for sustainability modelling and reporting. Therefore, data capturing processes need to align with the sustainability modelling and reporting requirements.
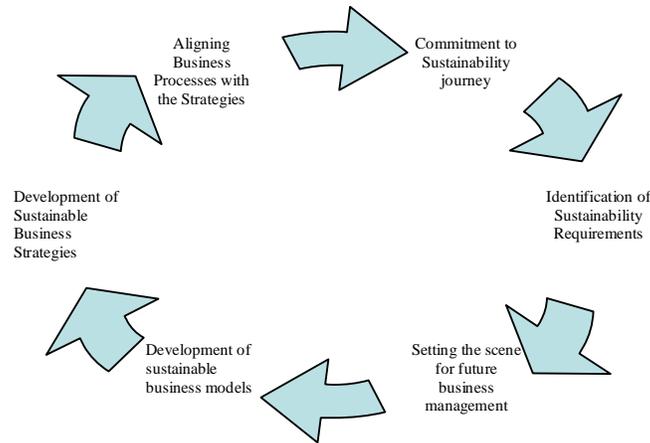
Figure 5: Overview of the impact of Sustainability Reporting

3.3 Issues of Sustainability Frameworks

An explicit framework helps bringing decisions and actions more closely in line with views and values of an organisation [34] and developing consistent sustainable business strategies, operational processes, and reporting. The existing frameworks can be broadly categorised into sustainability modelling frameworks, sustainability reporting frameworks and integrated frameworks for sustainability modelling and reporting. The modelling frameworks mainly address how to align business process, and the reporting frameworks provide guidelines on the content of sustainability reports. Existing modelling frameworks are developed independent of the reporting frameworks and vice versa. Some of these frameworks and systems support only one or two sustainability dimensions. Commercial and research organisations have introduced many different sustainability frameworks [35] e.g. a 10-dimension matrix based TBL reporting framework [7] , a generic framework for TBL reporting [1], NZBCSD sustainable development reporting framework [12], WBCSD framework [33], AA1000 framework [36], Project SIGMA framework [37] etc. These frameworks mostly describe what to report, how to report, timeframe for reporting, and sustainability indicators. The reporting framework is only suitable for the businesses that are already following sustainable business practices. But it is not suitable for businesses that need to transform themselves into sustainable business systems. Existing frameworks advocate fact-based reporting instead of scenario-based reporting and they are not aligned with the latest technologies. For example, SIGMA framework [37] provides a model that reflects what an organisation working toward sustainability might look like. Cartwright and Craig [38] propose a predictive model that presents a relationship between the growth in shareholder wealth and the impact of the business on the global environment. The GRI framework helps to elevate sustainability reporting practices [35]. The AA1000 framework provides guidelines for a stakeholders' engagement process that stipulate a process standard detailing how reporting and transparency can be improved. These frameworks do not

include the data modelling and information modelling steps that are pre-requisites for reporting. They are also not integrated with a coherent modelling framework. Hence, there is a potential gap between the information systems reporting capabilities and currently available reporting frameworks.

To address the inter-relationships of modelling and reporting processes, several organisations e.g. NZBCSD [12], WBCSD [33] have proposed integrated frameworks. Some of these frameworks address the iterative planning nature of the core business processes for aligning business along sustainable lines. They prescribe what to do during the planning process but without illustrating the models of the dynamic business systems and their inter-relationships. These frameworks except [39] have not addressed the representation of a sustainability model that integrates all the three sustainability dimensions. These frameworks are not properly supported by information systems frameworks and/or modelling methodologies and are thus not suitable for addressing the sustainable development and reporting requirements of businesses.

In order to address the above-mentioned problems and issues, a business needs a comprehensive and integrated framework for modelling and reporting that supports development of sustainability models, transformation of the existing business processes into sustainable business processes and reporting sustainability performances of the businesses.

4   An Approach to Design of Sustainability and Modelling Framework

Sustainable businesses need to address four key inter-related issues namely, representation of sustainability models, sustainability modelling processes and systems, sustainability reporting processes and systems, and a sustainability framework as shown in Figure 6. Model representation encompasses business process models, data models, information models, scenario models, simulation models, and sustainability models. All the above mentioned models except sustainability models are well defined in information systems literature. A sustainability model represents economic, environmental and social dimensions of businesses in an integrated mode as shown in Figures 3 and 7. Representation of a sustainability dimension in isolation does not provide the correct picture of the business. Sustainability models identify the impacts
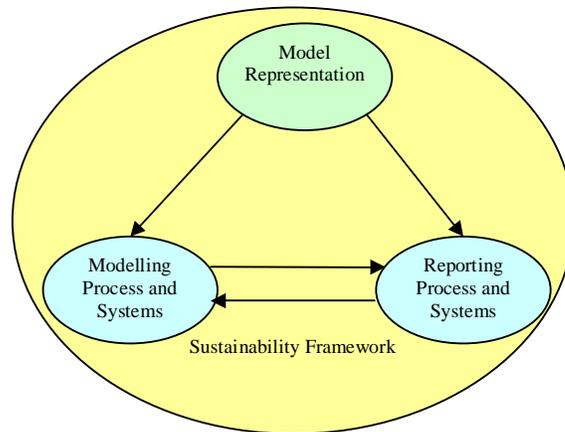

Figure 6: Sustainability Framework Development Processes

and influences of each sustainability dimension by modelling sustainability boundaries i.e. representation of sustainable and unsustainable patterns of a business. Therefore, we need to represent multiple sustainability issues within a model. This representation is not easy, as each dimension is comprised of many sustainability issues. An issue may also depend on some other issues. Each issue is influenced by several indicators related to the domain and cross indicators that are also related to other sustainability dimension(s). Each indicator can also be sub divided into finer elements. An overview of these relationships is presented in Figure 8.
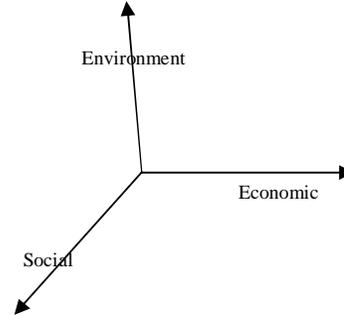

Figure 7: Representation of three dimensions of a Sustainability Model

Sustainability modelling is a process of modelling to create sustainable businesses. One modelling methodology is not sufficient to address the whole process. The process of exploring and defining strategic objectives can be modelled using systems dynamic modelling, scenario based decision systems modelling, simulation modelling, data modelling, information modelling, and balance scorecard methodologies. Business process modelling is required for business process improvement or business process reengineering and aligning the business processes with the newly developed sustainability strategies. Data
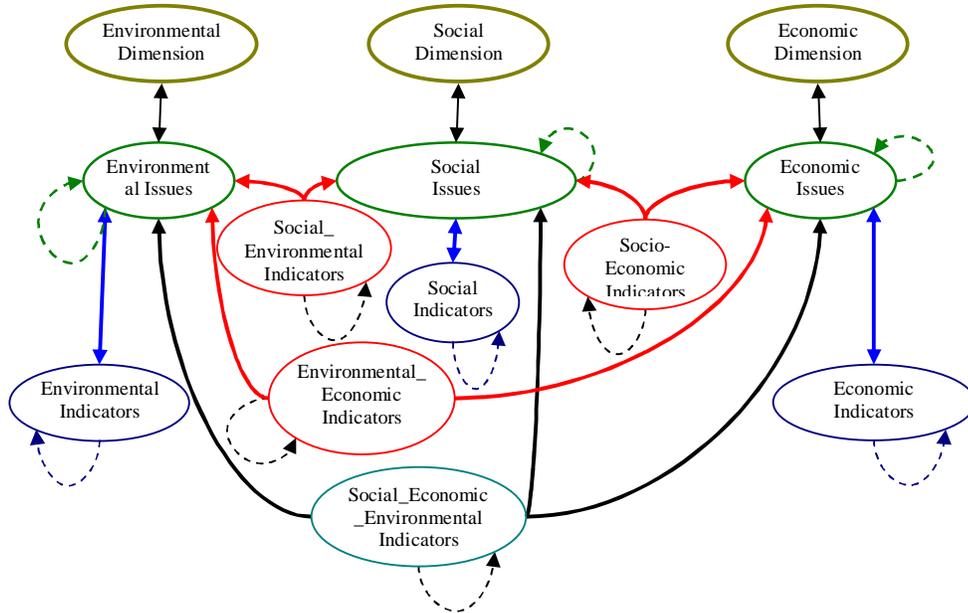

Figure 8: An overview of the relationships of sustainability dimensions

modelling and information modelling are required for sustainability reporting. Finally, all these models and modelling processes should be encapsulated in a generic and customisable framework that supports sustainability modelling and reporting in an integrated fashion.

A well designed sustainability modelling and reporting framework should support two key issues namely, inter-relationships between modelling processes and reporting processes, and should be supported

Figure 9: An approach to the development of sustainability modelling and reporting

by information systems framework as shown in Figure 9. An information model supports the sustainability reporting processes. The reporting process influences the modelling processes and vice versa. A sustainability framework encapsulates these three key issues and establishes relationships among them. Without the proper support from the information systems, it is impractical to address the above-mentioned SMR design and development issues. Therefore, we need to develop the right models, modelling and reporting processes and systems within a framework that is supported by information systems frameworks and methodologies for sustainable business development and reporting.
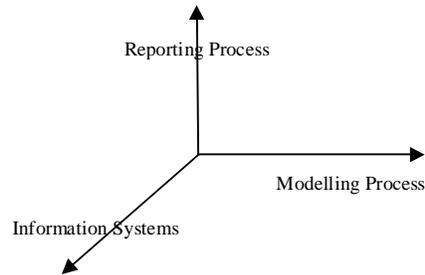
5 Realisation of the SMR Framework Development Approach

Sustainability models can be developed using a systems thinking approach that helps in shifting the focus from individual effects to interconnected systems [5] to shape the modelling framework. This includes looking into systems and processes, and how an individual item fits in with and affects the systems. This approach helps in identifying social and economic capital due to a shift in environmental management [5]. This approach can be supplemented by the balanced scorecard [40] and benchmarking methodologies for strategic planning. Balanced scorecard (BSC) and benchmarking help align key performance measures for development of strategic objectives of an organization; they provide management with a comprehensive picture of business operations, helping to define the critical success factors, strategic feedback and learning. This process considers implementation by federating actions of all the processes and services of an organization around a common understanding of its goals, and facilitates assessment and upgrade of strategy.

The SMR framework encapsulates systems dynamics, benchmarking and balanced scorecard methodologies and addresses the high level process of scenario modelling and decision modelling for development of sustainable strategies. This framework also includes among others, modelling dynamic business processes, scenario based decision modelling and information modelling. The modelling system organises sustainability indicators in a hierarchical manner based on key performance indicators and critical success factors of each sustainability dimension. The SMR framework couples the input and output of individual processes which sets each process within the overall business

system. The sustainability reporting framework supports extraction, transformation and reporting of qualitative and quantitative data required for sustainability reporting.

This research designs a modular and extensible generic architecture in line with the SMR framework that is flexible and customisable to suit the requirements of the business entity. Various methodologies, languages, packages and enterprise systems e.g. OO methodology, .NET framework, VB.NET, C#, SQL Server 2005, XML, Windows Workflow Foundation, Biztalk server 2006, iThink, and MS Excel, etc. are being used for the development of the SMR prototype. The framework and architecture of the prototype is scalable and customisable; it supports design and development of runtime data models and database, business object models and process models, scenario models and decision models. These models are stored in database and XML documents. The decision model of the SMR system supports development of sustainable strategies, business process re-engineering, capturing data relevant to sustainability reports and information modelling for analysing and preparing sustainability reports. The prototype will be implemented and tested using various business scenarios.

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