UNIVERSITY OF KWA-ZULU NATAL

Sustainable Development in South Africa through Research in the National System of Innovation

A thesis submitted in fulfilment of the requirement for the degree of Doctor of Administration School of Management, IT and Governance

by

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ABSTRACT

This research examined the role of research commercialisation for Sustainable Development (SD) in South African National System of Innovation (NSI) within the context of public administration. The introduction has provided the research objectives, problem statement and the research questions. It should be noted that the theoretical perspective served as a 'reference dictionary' that informs the rest of the research, the literature has also examined the role of research commercialisation for SD in the African region from an international perspective. Further, the pragmatic research design adopted provides the basis for undertaking mixed-method research, namely: quantitative followed by qualitative, supplemented by secondary documents and the methodological data analysis triangulation technique has facilitated the achievement of a 'whole greater than the sum of the parts'. In addition, the research methodology assessed the role of higher education institutions (HEIs) research commercialisation for SD. The findings identifying the HEIs as an important source of research for SD resulting in the findings showed that the HEIs face considerable constraints that hinder research commercialisation for SD, which include human resource capacity gaps, infrastructure and funding. The findings also identified HEIs-private sector collaboration as an important alternative avenue for research commercialisation for SD as a consequence the recommendations proposed that improving research commercialisation for SD should be high among the triple helix policy agenda. Finally, the recommendations also emphasised the importance of consolidating NSI gains, including efficiency in disseminating research results, efficient exploitation of new knowledge and technology transfer, leveraging the central role of the private sector in the NSI, effective application of intellectual property rights, broadening NSI actors' participation, simplification of policies and procedures and efficiency of allocation of funding.

DECLARATION

I ....Ms Wanjiru Gachie....................................... declare that

(i) The research reported in this dissertation/thesis, except where otherwise indicated, and is my original research.

(ii) This dissertation/thesis has not been submitted for any degree or examination at any other university.

(iii) This dissertation/thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

(iv) This dissertation/thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been referenced:
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Date ………………………………………

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This Doctor of Adminstration Degree is dedicated to my son Richard Munene Gachie, who tirelessly supported me during this endeavour.

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LIST OF ACRONYMS

AGOA	African Growth and Opportunity Act
AIDS	Acquired immunodeficiency syndrome
AMTS	Advanced Manufacturing Technology Sector
ARC	Agricultural Research Council
ASGISA	Accelerated and Shared Growth Initiative for South Africa

ASSAf	Academy of Science of South Africa
BERD	business expenditure on R&D
BRICS	Brazil, Russia, India, China, South Africa
BRIC	Biotechnology Regional Innovation Centres
BSC	Balanced Scorecard
CeSTII	Centre for Science, Technology and Innovation Indicators
CHE	Council on Higher Education
CE	Community engagement
CIDAUT	Canadian International Development Agency
CIS	Community Innovation Survey
CSIR	Council for Scientific and Industrial Research
CO_2	Carbon dioxide
COMESA	Common Market for Eastern and Southern Africa
DACST	Department of Arts, Culture, Science and Technology
DEAT	Department of Environmental Affairs and Tourism
DST	Department of Science and Technology
DHET	Department of Higher Education and Training
DoE	Department of Education
DoL	Department of Labour
DTI	Department of Trade and industry
DVC	Deputy Vice-Chancellor
ECLAC	Economic Commission for Latin America and the Caribbean
ECOWAS	Economic Community of West African States
EDD	Economic Development Department
EIA	Environmental Impact Assessment
EKC	Environmental Kuznets Curve
EU	European Union
FDI	Foreign direct investment
FRO	Foundation for Research Development
GAIN	Global Adaptation Institute
GERD	Gross domestic expenditure on R&D
HCD	Human capital development
HEIs	Higher education institutions
HEMIS	Higher Education Management Information System
HEQF	Higher Education Qualifications Framework
HIV	Human immunodeficiency syndrome
HSRC	Human Sciences Research Council
ICT	Information and communication technology
IDRC	International Development Research Centre
IKS	Indigenous knowledge systems

IMF	International Monetary Fund
IP	Intellectual property
IPAT	Impact population affluence and technology
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual property rights
IPR-PFRD	Intellectual Property Rights from Publicly Financed Research
KPI	Key performance indicators
LDCs	Less-developed' countries
M&E	Monitoring and evaluation
MDG	Millennium Development Goals
Mintek	Council for Mineral Technology
MIS	Management information system
MRC	Medical Research Council
NACI	National Advisory Council on Innovation
NDP	National Development Plan
NEMA	the National Environmental Management Act
NEP	National Equipment Programme
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
NGP	New Growth Path
NIPMO	National Intellectual Property Management Office
NNEP	National Nanotechnology Equipment Programme
NPC	National Planning Commission
NQF	National Qualifications Framework
NRDS	National Research and Development Strategy
NREN	National Research and Education Network
NRF	National Research Foundation
NRTF	National Research and Technology Foresight
NSI	National System of Innovation
NSMM	New Strategic Management Model
NSSD	National Strategy for Sustainable Development
NSTF	National Science and Technology Forum
OECD	Organisation for Economic Cooperation and Development
PhD	Doctor of Philosophy
PMI	Project Management Institute
PMIS	Policy management information system
PRI	Public Research Institute
R&D	Research and development (sometimes Research and experimental development)
RIMS	Research Information Management System
SD	Sustainable Development

S&T	Science and technology
SA	South Africa/ South African
SADC	Southern African Development Community
SALT	Southern African large Telescope
SANReN	South African National Research Network
SARChl	South African Research Chairs Initiative
SARIMA	Southern African Research and Innovation Management. Association
SET	Science, engineering & technology
SETI	Science, engineering and technology institutions
SINTEF	Norwegian Institute of Technology
SKA	Square Kilometre Array
SME	Small and medium enterprises
SNA	System of National Accounts
SPII	Support Programme for Industrial Innovation
STI	Science, technology and innovation
STU	Swedish National Board for Technological Development
SST	Sustainable structural transformation
TBL	Triple Bottom Line
TENET	Tertiary Education and Research Network of South Africa
THRIP	Technology and Human Resources for Industry Programme
TIA	Technology Innovation Agency
TTO	Technology Transfer Office
TYIP	Ten-Year Innovation Plan
UK	United Kingdom
UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USPTO	United States Patent and Trademark Office
WCED	World Commission on Environment and Development
WEF	World Economic Forum
WSSD	World Summit on Sustainable Development
WRC	Water Research Commission
US	United States of America
VTT	Valtion Teknillinen Tutkimuskeskus

CHAPTER ONE

INTRODUCTION

1. RESEARCH BACKGROUND

This chapter provides introduction of this thesis by providing among others the research background, research objectives, problem statement and the research questions. The terms study, thesis and research have been used interchangeably to refer to this document and or undertaking.

1.1 INTRODUCTION

The thesis examines the construct of Sustainable Development (SD) in South Africa through research in the NSI within the public administration context. Using the role of research as the central theme, this thesis examines South Africa's National System of Innovation (NSI) landscape for SD within the public administration context. The research considers SD as the intent of undertaking research commercialisation. Further, the thesis focuses on how NSI institutional and organisational structures, policies and procedures can be applied for SD as a result of commercialisation of research. Individual constructs examined in the thesis include (sustainable) development, research and knowledge management, innovation, public administration and policy and the NSI as illustrated in Figure 1.1-1. The assumption is that the NSI actors produce different types of research mainly fundamental, basic, applied and strategic research, which can be commercialised with the presence of relevant support. The thesis provides a comprehensive research on the historical, present and anticipated future of the South African NSI to the network actors.

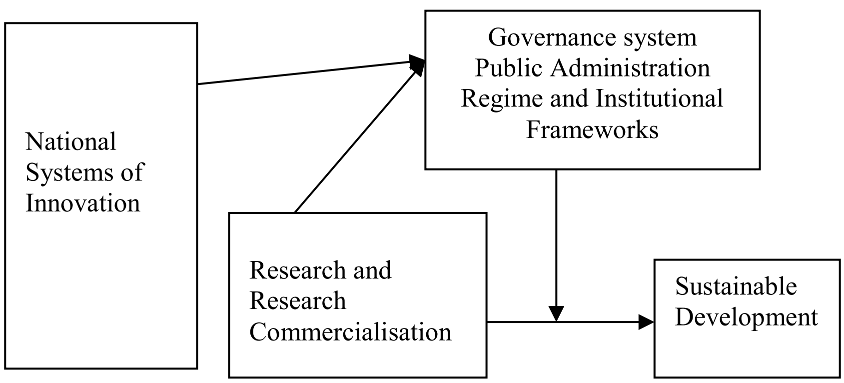


Figure 1.1-1: Overview of the 'sustainable development through research in the NSI' framework

The South African Department of Science and Technology (DST, 1996) policy framework, the first explicit policy intention and intervention for developing a formal NSI, signifies the point of departure for this undertaking. Other important documents in the research departure include

Country Reviews such as OECD 2007a; 2007b and the SA DST Ministerial Review Committee in 2011/2012, henceforth referred to as SA DST Ministerial Review Committee (2012).

The thesis examines South Africa's NSI performance in science, technology and innovation (STI) with particular reference to the (i) size and shape of the NSI; (ii) NSI governance and structure; (iii) resourcing and financing, including human resource development; (iv) capacity to monitor and evaluate the impact of the system towards transition into the anticipated knowledge-based economy by the SA DST Ten-Year Innovation Plan (TYIP) (2008-2018) in achieving of national development priorities; and (v) readiness of the system to adapt to both local and global changes facing South Africa are examined. Recommendations are made by constructing a framework for strengthening and enhancing South Africa's STI's capabilities, with particular reference to: (i) the structure and governance of the system; (ii) human resource and infrastructure capabilities; (iii) the roles and responsibilities of different actors within the NSI; (iv) the roles and responsibilities of different public departments within the NSI such as the DST and Department of Trade and industry (DTI), associated centres and the relationship with other government departments; and NSI financial practices and funding requirements. Furthermore, a framework is formulated using literature and primary data on (sustainable) development, research which includes knowledge management, innovation, the NSI and public policy and administration.

In paving the way forward, the research utilises South African NSI, policies and Country Review in the literature review, which also serves as secondary data for the research analysis. The policy documents and Country Reviews include the International Development Research Centre, IDRC in (1993), Towards S&T Policy for a Democratic South Africa Mission Report of July 1993, South African White Paper on S&T in 1996, South African National Commission on Higher Education, 1996, The South African NSI Country Review Report by the Organisation for Economic Cooperation and Development (OECD, 2007), The New Growth Path (NGP) Framework by the South African Department of Economic Development (EDD), 2010, The Diagnostic report by the South African National Planning Commission (NPC, 2011a), National Development Plan (NDP): Vision 2030 by the NPC, (2011b) and the SA DST Ministerial Review Committee in 2011/2012.

South African policy documents and Country Review indicate that the NSI has not yet occupied a strong conceptual and practical space in the critical fields of endeavour necessary for the achievement of national purposes. Therefore, this research identifies the adequacy and/or lack thereof of the existing South African policy documents to inform the responsiveness, strengths and weaknesses of the NSI in addressing sustainable development in South Africa through research in the NSI. The study is undertaken in the context of public administration, which is viewed as a key element in the web of the construct of transition from government to governance, where the government influences and is influenced by other NSI actors and institutions.

This research is underpinned by public administration processes and policies as tools for realising SD through research commercialisation in the NSI, geared to serving the needs of South African citizens. The assertion is supported by official figures by South African Department of Environmental Affairs in November (2011) of the National Strategy for Sustainable Development (NSSD1, 2011-2014), where the developmental challenges facing South Africa are understood to include: 13.4% of households living in informal dwellings, 7.6% of households not having access to water supply from a safe source, 27.8% of households not having access to sanitation, 17.4% of households not having access to electricity and adult illiteracy rate of 19.2%. The aforementioned developmental concerns pose a threat not only to the achievement of a sustainable society in the long term, but also to the ability of government to meet short-term developmental objectives outlined in the NSSD1. As a consequence, the imperative is to explore ways for achieving SD through both the NSI and Triple Helix III, where university research largely and, to some extent, business expenditure on R&D (BERD) play a vital role. The research also reviews requirements for enhancing innovation for economic growth, jobs, better health and quality education.

The literature draws from, *inter-alia,* textbooks, websites, journals, periodicals, newspapers and legislative and policy documents relevant to NSI and public administration. In paving the way forward, South African NSI and policy country reports have been utilised in the literature, which also serves as the secondary data.

1.2 CHAPTER OUTLINE

The interplay of the following nine chapters summarised below makes up this research. This research has made use of present tense, with each chapter commencing with an introduction and concluding with a summary, which brings together the main concepts and provides continuity throughout the thesis.

- Chapter 1 is the current chapter that basically introduces and provides the chapter outline, and the motivation for it among others.
- Chapter 2, ("sustainable development: the role of innovation in the South African economy") examines the construct of SD mainly from a South African perspective. This theoretical perspective serves as a 'reference dictionary' that informs the research analysis chapter.

- Chapter 3 ("public administration and public policy in South Africa") undertakes literature review with regard to public policy and public administration in South Africa. In this research context, the NSI policy framework has been used to provide with a foundation for reviewing the South Africa's collective efforts among the NSI actors in an integrated and holistic manner.
- Chapter 4 ("National innovation system: main features and performance") reviews the NSI construct, namely: the history, governance, present policies and institutional structure. The literature review provides with a landscape of the South African NSI that is utilised in this research to provide with recommendation and construct the framework for improving the NSI effectiveness and efficiency.
- Chapter 5 ("African region NSI and SD trends") examines the construct of SD as a result of research commercialisation in the NSI in the African region. This Chapter adds on to the importance of intra-African region NSI dialogue and draws out both context-specific and generic country experiences that can inform policy developments in South Africa.
- Chapter 6 ("International NSI and SD trends") undertakes literature review on the construct of SD as a consequence of commercialisation of research in the NSI from an international region perspective in order to draw out both context-specific and generic transferable country experiences that can inform policy developments in South Africa.
- Chapter 7 ("Research design") explains the ontological or epistemological view of this research. The chapter presents the research design used to examine the NSI landscape, specifically with respect to the HEIs.
- Chapter 8 ("Result and Discussion") presents the research analyses and discussion in order to identify main themes for later framework construction and research recommendations.
- Chapter 9 ("Recommendation and Conclusion"), provides recommendations that form the centrepiece that should be adopted for the efficient and effective NSI functioning. The proposed recommendations are based on the results and discussion from chapter 8. Finally a conclusion based on the findings, undergird by the research objectives and problem statement is drawn.

Having provided the research outline the chapter next presents the research problem.

1.3 RESEARCH PROBLEM

This research examines the role of research for SD in South Africa. There exists both empirical and analytical literature for example, Sachs (2001), Paterson, Adam and Mullin (2003), Buys, (2004;2007) and Soares and Podcameni (2014) that supports the need for examining the contribution of research by diverse South African NSI actors. Leading up to 2013, South Africa's academic research databases have shown that no stand-alone research on SD in Least developed countries (LDCs) as a result of research commercialisation in the NSI has been undertaken. A research gap also exists because most in-depth studies on the topic of (sustainable) development have been conducted by researchers from fields such as in environmental, leadership and engineering studies (Shriberg, 2002; Henson, Missimer & Muzzy, 2007; McNamara, 2008). Whilst much discussion of SD tends to focus on barriers and challenges, this research envisions a positive future for SD in South Africa as a product of research commercialisation in the NSI.

Further, analysis of academic research databases has shown that most research in the field of innovation is focused on the business sector, while overlooking the contribution of other NSI actors. Therefore NSI literature has typically omitted an in-depth examination of other system actors affected by framework conditions and policies. Consequently, exploring the issues that have contributed to the loosening of the connections and interactions between the NSI actors South Africa is essential.

The old management adage that "to manage one must measure" remains accurate in the 21st century. However, the question of how to manage research commercialisation in order to contribute to (sustainable) development lacks clarity. South Africa requires SD through research in the NSI indicators to measure the significance of the construct in realising the various policy objectives.

According to Holmberg and Samuelsson (2006:10), "how we do research is as important as what we do research on". As such, research should not just report the field but shape the field. The United Nations Conference on Trade and Development, (UNCTAD 2007) points out the importance of innovation and policy in generating initiatives to promote a better country-level performance. However, the policy and research commercialisation domains of the NSI and technology are, to a large extent, disconnected from those dealing with (sustainable) development issues (Kivimaa & Mickwitz, 2006; Nilsson, Rickne, Kokko & Virgin, 2008:2). The study argues that innovative activities should occur within all the three relevant dimensions of SD, namely: economic, social equity and environmental/ecological systems. However, the South African government faces a challenge of ensuring progress in terms of the three interdependent and mutually reinforcing pillars outlined by the Johannesburg Declaration on Sustainable Development (2002:1) and the United Nations Conference on Environment and Development (UNCED, 1992) "Agenda 21" takes place and the Economic Commission for Latin America and the Caribbean, ECLAC (1992) report. In summary, the ECLAC (1992:6) proposes the following thrust:

> ...environmentally sustainable growth with equity, a democracy, is not only desirable but possible. Indeed, social equity cannot be attained in the absence strong, growth, such growth likewise calls a reasonable degree social and political stability and this in turn means meeting minimum requisites of equity. …It is this interdependence between growth and equity that it is necessary to advance towards these objectives simultaneously rather than sequentially and this represents an unprecedented challenge…..

The capacity to innovate in scarcity conditions (for example conditions facing LDC in the African region) is one of those crucial micro-potentials, which has important implications for social equity, industrial structure and technological specialisation (Srininvas & Sutz, 2008:10). Measurement activities, production of indicators and regular collection of systematic data are key ingredients of the knowledge ecology for the purpose of tracking performance progress and assessing 'structural transformation' by policy makers (Foray, 2010:101). The term 'structural transformation' has been applied in this research context, according to Syrquin (2010), to refer to a process in which the relative importance of different sectors and activities within a national economy changes in terms of both composition and utilisation. One of the main challenges facing LDC in the African region is the promotion of structural transformation, while mitigating the associated environmental impacts.

This research also reviews social innovation in South Africa, a concept which relates to innovation for social equity and remains ill-understood and poorly researched in comparison to its counterparts in business and S&T. Although South Africa is confronted with urgent priorities in terms of socio-economic development, this research recognises that the role of social innovation in the NSI is currently under-conceptualised and under-developed.

In the realisation of the proposed TYIP of 2008, the NSI perspective will primarily concern the flow and the impact of the knowledge ecology on economic development. The importance of transforming knowledge ecology into adaptive innovative systems have been explored by scholars such as Heclo (1978), Rhodes (1997), Enos, Lall & Yun, (1997), Deleon and Martell (2006), David and Metcalfe (2008) and Foray (2010:97). This research views knowledge ecology according to Foray (2010:97) as encompassing activities of R&D institutions as well as applied research activities of public and private institutions including programmes for training and educating the technical workforce.

South African Higher education institutions (HEIs) in varying degrees combine the functions of education, research and entrepreneurship (Gordon & Craig, 2001; Mowery & Sampat, 2007). As research institutes, the fundamental issue is to establish whether the mergers and the emerged landscape in South African HEIs have prompted an increase in research production within the new institutional configurations. In a paper delivered at the World Bank Conference of Economic Development, Lundvall (2007:12) states that: "A general conclusion is that the role of higher education needs to be assessed in the wider context of the NSI and that higher education policy needs to be coordinated with a wider set of innovation policies". Veugelers, Tanayama and Toivanen (2009:265) state that "hampered by the lack of good data, embarrassingly few economic studies assess which factors can explain good performance of universities". This thesis, therefore, seeks to determine the policies, interface structures, positions, funding and incentives avenues in place (or absent) and the relevant interventions for strengthening the HEIs within the NSI.

South Africa has made significant SD progress over the past 15 years. However, significant development challenges need to be addressed in a SD manner. Despite emerging literature at international levels, for example Ernst and Kim (2002) and Jensen, Johnson, Lorenz and Lundvall (2007) recognise the significance of NSI partnerships and interactions, both formal and informal/traditional among the NSI actors. However, empirical research on the interactions remains scarce in the African region, including South Africa. As a consequence of the South African-anchored departure point, the construct of SD within the NSI as a result of research commercialisation in the African region and international trends will be examined. Having presented the research problem, the next section presents reasons for choosing the topic.

1.4 REASONS FOR CHOOSING THE TOPIC

The study is motivated by the dearth of research and literature required for SD in South Africa in the NSI in an integrated format. Activities and subsequent examination of research for SD agenda in developing economies is still in the early stages. This research could assist the NSI actors to develop appropriate tools, policies and programmes that respond to the gaps identified while building on the current strengths and capabilities. Rationales for public policy intervention such as the Green and White Paper of 1996 include the fact that a 'problem' had been identified and public agencies had the 'ability' to solve or mitigate the problem; otherwise without fulfilment of the aforementioned two conditions, no policy intervention would be required.

According to the OECD (2007b) and the SA DST Ministerial Review Committee (2012), there is much that should be done to optimise the functioning of the South African NSI. The South African Community Innovation Survey (CIS) and National Survey of Research and Experimental Development in South Africa: Main Results 2005-2007 (DST/HSRC, 2011) states, that "countries are still learning to understand the determinants and processes of innovation".

The National Survey of Research and Experimental Development are conducted annually on behalf of the DST by the Centre for Science, Technology and Innovation Indicators (CeSTII) at the Human Science Research Council (HSRC). However, the SA DST Ministerial Review Committee (2012:183) argues that the generation of successive annual reports has not led to the generation of a prospective National S&T Expenditure Plan, the beneficial results of which might be expected to include direct examination of the R&D and innovation requirements and assistance of central line departments in establishing the necessary NSI relationships.

The specificities of precisely how innovation happens in sites of productive activity (private sector, government departments, HEIs, and communities, among others) are under-researched (SA DST Ministerial Review Committee, 2012:99). An innovation policy and performance cross-country comparison by OECD (2005b) and OECD (2007c) indicates that the platform for such systemic learning has not yet been provided in most of the OECD countries, which shows that South Africa is not alone in NSI policy learning. There is a lack of survey or evaluation aimed at assessing the extent and status of the knowledge infrastructure within South African NSI (SA DST Ministerial Review Committee, 2012:163).

Literature, for example Schumpeter (1939), Milbergs, Kalweit and Boege (2007), Bhatta (2003) and OECD (2003:11) acknowledges the critical role of the NSI linkages among various NSI actors as being vital in the innovation process feeding into the national economic development. The SA DST Ministerial Review Committee (2012:164-165) notes that the "country must have the means to review its performance".

Manzini (2012:2) observes that the usefulness of the concept of NSI in the developing world contexts is a significant point for undertaking research and deliberation and further states "that a case is yet to be made for the appropriateness or expediency of the NSI concept as a conceptual framework for understanding and shaping the behaviour of knowledge driven institutions within a developing country". In this research context, the concept of LDC is based on the standard United

Nations Statistics Division classification (composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings) (United Nations, 2005). The National Advisory Council on Innovation (NACI, 2007:81), Background Report to the OECD Country Review of South Africa's NSI, states that “the dearth in research in the aforementioned topic is not limited to the South African context only, but affects LDC in the African region”. The concept of NSI has yet to gain currency both in terms of a wider than traditional R&D activities view and in fully being absorbed into the strategies of key actors (NACI, 2007:79-80; OECD, 2007b:89). During the past two decades, there has been a growing interest among scholars for example, Lall and Wangwe (1998), Cassiolato and Lastres (2008), Fagerberg, Mowery and Nelson (2005), Dutrénit (2004), OECD and Eurostat (2005) and Wade (2010), on the importance of exploring the integration of various policy mixes. The various domains of innovation are highly related and cannot be meaningfully separated in the real world (Ashford, 2004). The research views the separate worlds of South African policies as a barrier within the NSI. For the reason, “systemic problem descriptions” (Schot, Geels, Kemp, & Weber, 2002:6) in addressing the research topic is used. The research examines the ‘action directives’ or ‘action direction’ as well as the various measures (locally and internationally) of the policy mixes under investigation. The dearth of research contribution to SD in LDC through research in the NSI impedes the formulation, implementation and evaluation of appropriate policy mixes. The theme of ‘policy integration’ proposed by the ECLAC (1992) has since been strongly reverberated by the OECD’s publications and reports. Handfield, Monczka, Giunipero and Patterson (2011:118) offer a broad definition of integration as “the process of incorporating or bringing together different groups, functions, or organisations, either formally or informally, physically or by information technology, to work jointly and often concurrently on a common…related assignment or purpose”. Integration ensures that the pieces come together as a “whole” at the right time “pulling together” (Stuckenbruck, 1998:69; Morris, 2004:28). From this research milieu, policy integration must be made to happen. More than fitting components together the system has to function as a whole (Stuckenbruck, 1998:69; Lundvall, Johnson, Andersen & Dalum, 2002:228-230).

The absence of research reflects the lack of strong foundational NSI framework condition and policies, an indispensable starting point for analysing the contribution of South African research within the NSI. On similar principles to the SA DST Ministerial Review Committee of 2111/2012 this thesis rejects the axiom that ‘restructuring is an admission of lack of strategy’ because redesigning the NSI is critical for achieving a governance architecture that is fit for purpose.

The research adopts three broadly diverse situations for ‘‘doing things differently’’ in ‘scarcity-induced innovations (SII)’ for addressing SD in South Africa resulting from research commercialisation in the NSI (Srininvas & Sutz, 2008:4): (i) searching for different solutions to problems that have been already solved because existing solutions are inappropriate or unaffordable, including the necessity of adaptation stemming from specificities of natural endowments; (ii) developing innovative efforts to respond to prospective users who face scarcities of some type; and (iii) fostering specific ‘‘scarcity-driven’’ heuristics to deal with well identified but not yet solved problems. From this research standpoint, the SII situations arise from either institutional or physical lack of supporting organisations, laws and technical instruments or from socio-economic, where according to Srininvas and Sutz (2008:5) (a) when problems affecting developing societies have not been tackled at all, (b) there is existence of policy biases, or (c) the solutions available are unaffordable, and new searching avenues should be pursued.

In conducting this research, two assumptions are made. First, the research assumes that exploring the linkages among South African NSI actors is the key for research commercialisation and SD. Second, the research assumes that developing a strong framework for research capabilities and knowledge base is critical for research commercialisation and SD. Despite the first formal NSI policy initiative of the 1996 Green and White Papers, South Africa is confronted by a number of problematic issues, which include (i) establishment of an effective approach to governance (both system-wide and intra-sectoral); (ii) the need to achieve greater inclusion and equity across various sectors of society; (iii) the need for a more effective resourcing framework and; (iv) the problem of inadequate knowledge base and the need for more effective systems of information steering capabilities.

In particular, a greater clarification of roles of various NSI actors is needed for greater coordination and coherence. The SA DST Ministerial Review Committee (2012:164) notes that “there is no comprehensive synopsis available, even in conception, which reflects the desire to be able to ‘see’ the system in its totality, and how it might be fulfilling its function... there seems as yet to be no provision for sustained research into the dynamics of the system in order to inform steerage”. The NSI actors or institutions have also been referred to as ‘players’ as in Edquist (1997:1-2).

The Community Innovation Survey (CIS), which uses the OECD Manual guidelines conducted by the HSRC in South Africa every four years, namely: the South African CIS National Survey of Research and Experimental Development in South Africa: Main Results 2002-2004 (DST/HSRC, 2009); Main Results 2005-2007 (DST/HSRC, 2011); and Main Results 2009-2010 (DST/HSRC,

2013) provides helpful unit of analysis (some excellent windows onto selected parts of the system) with respect to both the private and public sectors. However, the CIS is not designed to address issues of NSI framework functionality in totality, which requires different unit of analysis and investigative tools.

Research within the NSI, especially at the national sphere, is valuable for developing appropriate policies for shaping and predicting NSI actors' behaviour (Liu & White, 2001:1093; Hippel von & Jin, 2009:19-21; Klerk, Hall & Leeuwis, 2009:21). While on-going OECD country reviews and policy documents discuss the governance of NSI and related policy and the required government and institutional responses, two major deficits have been identified. First, the various schools of research have not been fully brought together, resulting in a lack of a comprehensive, theoretically derived framework (Jordan, 2008:22; Hillman, Nilsson, Rickne & Magnusson, 2011:403). Second, with a few exceptions within the OECD country reviews, there is a shortage of systematic qualitative and quantitative analysis of the impact of NSI governance arrangements, especially on the construct of research commercialisation for (sustainable) development, which this research seeks to address.

In 2008, the DST drafted the TYIP (2008-2018), aimed at driving South Africa's transformation towards a knowledge-based economy, from the historically resource-based economy using various output indicators. However, despite political rhetoric to the contrary, the policies and processes set up to facilitate or foster innovation remain more or less disconnected from SD considerations and policies (Nilsson et al., 2008:1; Hillman et al., 2011:403). Quests for a knowledge-based economy have become "holy grails" of public policy worldwide. The OECD (2007b) Country Review and the SA NSI Ministerial Review of 2012 and other policy documents such as the White Paper of 1996 and NGP by EDD (2010) indicate that South Africa requires an innovation policy shift, but few, if any, explicitly make clear what the shift means in practice and how the policy instruments ought to be restructured to support the knowledge economy and which new instruments should be developed.

Notwithstanding, according to the NACI (2010), the DST is unlikely to achieve some of the outlined output targets for a number of reasons, the main one being the lack of alignment within government structures. As a result, the proposed DST TYIP faces a risk of being dissipated in the multi-voice debate, unless the innovation strategy is made more concrete. The OECD (2001a:6) defines an innovation strategy as comprising "a coordinated set of participatory and continuously improving processes of analysis, debate, capacity-strengthening, planning and investment, which integrates the economic, social and environmental objectives of society, seeking trade-offs where this is not possible". Undertaking this research within the context of NSI provides a suitable basis for exploring specific South African innovation, (sustainable) development and research strategies and policies.

This study has observed that in LDC NSI research is at a preliminary stage. Manzini (2012:1) states that "the NSI approach towards understanding how technological innovation operates within national economic systems is relatively new. There is, therefore, a need to develop theoretical tools to sharpen … understanding of this conceptual framework". Furthermore, the SA DST Ministerial Review Committee (2012:83) maintains that NSI impact evaluations are few and far between, so that deeper tests of strength are absent. To contribute to development efforts will require adapting the NSI framework to reflect the realities of the Africa region and LDC, in particular (Johnson, Edquist & Lundvall 2003; Edquist, 2005; Stein, 1992; Lall & Teubal, 1998; Griffin, 1996). According to Marcelle (2011:4), "the biggest challenges facing countries in the developing world include poor health services, lack of affordable housing, environmental sustainability, energy, poverty, urban management, and a range of other issues that affect quality of life". Correcting market limitations such as problems of appropriability of innovations, weakness and failures in financial and labour markets, poor technology infrastructure, dysfunctional education and training systems, inadequate intellectual property (IP) rights regimes and regulatory systems, and poor support for investment in innovation that characterise many least LDC and a few LDC often requires direct interventions (Lall & Teubal, 1998; Lall & Petrobelli, 2002). The aforementioned limitations, are comparable to Bekkers, Edelenbos and Steijn (2011a:5; 2011b:212) use of the terminology 'wicked challenges' with a 'wicked character', which require the implementation of tailored, appropriate policy mixes along the continuum between, for example, strict non-intervention and provision of preferential treatment for pre-selected supported innovation policies and strategies periodically. This research views the achievement of convergence, whether tightly coordinated or loosely coordinated, as the greatest imperative within the South African NSI. The challenges are 'wicked' because of lack of clarity on what the relevant causes are, what the possible effect of possible strategies are and what criteria should be used to assess the wanted and unwanted effects (Bekkers et al., 2011b:212). In Rittel and Webber's (1984) terminology, many of societies' problems are no longer "tame" to be solved by hierarchical or technocratic models of leadership, management or knowledge creation. Instead, the challenges are 'wicked', requiring knowledge and action to be developed across boundaries of culture, discipline, sector and business models. The 'wicked' problem as stated by Grint (2010:14) and Goodwin (2011:60) "cannot simply be removed from its environment, solved and returned without affecting the environment.

Moreover, there is no clear relationship between cause and effect". Even though the 'wicked challenges' or 'national crisis', cannot be resolved in a short period, this research topic is driven by the idea that the wicked problems actively require new approaches through collaborative processes. The SA NPC (2011a) diagnostic document and NDP: Vision 2030 by NPC (2011b) indicate a 'national crisis' facing South Africa's ability to map a pathway to (sustainable) development. In what amounts to crisis conditions, the transition into the knowledge economy and innovation will require diversifying and amplifying stimulus to South Africa's existing resource and efficiency based economic system.

The African region continues to consider the regional approach as the best tool for development Some of the regional initiatives in Africa, for example, Common Market for Eastern and Southern Africa (COMESA), Economic Community of West African States (ECOWAS) and Southern African Development Community (SADC) have neither delivered much to uplift the economic conditions of member countries nor ensured sustainable growth and liberalisation (UNCTAD, 2009:9-17). However, the issue at hand is not whether Africa should integrate or not; there is a political consensus for regional integration in Africa. The issue is how research in topics such as SD in South Africa as a consequence of research commercialisation in the NSI can maximise the benefits of African regional integration. Similarly, requirements for the emergence of "sustainability-oriented innovation systems", a concept suggested by Stamm, Dantas, Fischer, Ganguly and Rennkamp (2009) should further be explored in the African context. South Africa lacks mechanisms that are contextually sensitive to the commercialisation of publicly-funded research. To this end, the next section presents the research objectives.

1.5 RESEARCH OBJECTIVES

The primary aim is to examine the construct of SD in South Africa through research in the NSI culminating in the formulation of an integrated framework.

The specific objectives of this study are to:

- Review the integration of various policies namely: (sustainable) development, research, S&T, innovation and public administration landscape in the NSI readiness to address (economic, social and environmental) challenges in South Africa.
- Assess the role of South African HEIs in research commercialisation for SD.
- Appraise the linkages between the HEIs, the private sector and government strengthening the character of the NSI.
- Propose the main elements of the NSI from African regional and international literature on the construct of SD in South Africa through research in the NSI.

- Provide recommendations and develop an *integrated* framework for extrapolating by the diverse NSI actors.

1.6 RESEARCH QUESTIONS

Using Bassey's (1999:69) metaphor from the field of research, a research question is compared to the engine which drives a train of inquiry. Concerning the challenges of examining SD in South Africa resulting from research commercialisation in the NSI, the crucial task lies in formulating good research questions in order to arrive at arguments that are applicable to the South African context. The formulated research questions are important not only for reviewing the research phenomenon, but also for transferring (extrapolating) the research outcomes to the relevant NSI actors. In addressing SD in South Africa as a consequence of research commercialisation in the NSI, the basic questions for undertaking a national-level system analysis is to address the system structure, the system dynamics and the system performance. This includes determining whether the NSI structure and coordination is highly centralised, multi-centric or highly decentralised. This also includes addressing the system dynamics that brings the activities and the NSI actors together for research commercialisation and the system performance and the structure of the NSI.

The primary research question: What is the role of research for SD in South Africa through the NSI?

The secondary research questions are:

- How can integration of various policy mixes namely: (sustainable) development, science, technology, innovation and public administration in the NSI are governed in readiness to address (economic, social and environmental) challenges in South Africa?
- What is the role of South African HEIs in research commercialisation for SD?
- How are the linkages between the HEIs, the private sector and government positioned in strengthening the character of the NSI?
- Which are the main elements of the NSI from African regional and international literature on the construct of SD in South Africa through research in the NSI?
- How can the various components of an integrated framework be utilised by the diverse NSI actors for SD through research in the NSI?

Having provided the introduction, the next section provides a range of key definitions on the construct of SD as an outcome of research commercialisation in the NSI.

1.7 DEFINITION OF KEY TERMS

This section explores the key terms related to the constructs of SD in South Africa through research in the NSI. The terms will be defined and discussed in detail in later chapters.

1. **Sustainability:** even though the concept of sustainability has largely defied precise definition, the World Commission on Environment and Development (WCED, 1987) defines sustainable development as the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs".
2. **Development:** in this research context, development is defined according to Pieterse (2010:3), "as the organised intervention in collective affairs according to standard of improvement".
3. **Commercialisation:** this thesis defines commercialisation according to South African Intellectual Property Rights from Publicly Financed Research (IPR-PFRD) Act, (2008:3): "means the process by which any IPR-PFRD and development is or may be adapted or used for any purpose that may provide any benefit to society or commercial use on reasonable term".
4. **Innovation:** this study views innovation as the result of a complex interaction among various actors and institutions (Freeman, 1996:30, OECD, 1997:11-12) and defines innovation according to the OECD and Eurostat (2005:46) as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.
5. **Higher education institution (HEIs):** An institution means any HEIs contemplated in the definition of "higher education institution" contained in section I of the South Africa Higher Education Act (1997) (Act No. 101 of 1997). The NSI is defined in this research according to Freeman (1987:1), as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies".
6. **Productive sector:** from this perspective, an encompassing definition of the productive sector in South Africa is one that includes all aspects of the private sector, including agriculture and the informal sector.

1.8 LIMITATION OF THE RESEARCH

The limitations did not hamper the research process or the outcome of the research. The research acknowledges that the NSI framework lacks comparable approaches and indicators across LDCs. There are also diverse views on the appropriate level of analysis: the sub-national level, the national level, the pan-regional level or the international level. Systems of interaction and innovation exist, to some extent, at all the levels. The different levels increasingly interact to further complicate the task of analysing innovation systems.

Despite all efforts to obtain the questionnaire from research respondents, a 40% response rate was achieved, though a higher response rate would have improved the representativeness of the data. Nevertheless, the data collected from the five participating institutions provides a solid foundation that provides for a dialogue on interventions for strengthening the triple helix linkages in South Africa's NSI.

A fortnight after sending out the questionnaire, two completed questionnaires were received. Three reminders were sent during a period of one month and two more questionnaires were received. By the end of the second month, a conclusion was arrived at where the supervisors sent out an email requesting the remaining participants for their participation (Appendix 1). As a result, one more questionnaire was received. Four research participants elected to withdraw from participating, citing various reasons such as HEIs not commercialising or their having no time to participate. To this end, this research provides the chapter summary.

1.9 SUMMARY

This chapter has provided the research introduction by outlining among others, the research background, research objectives, problem statement, research questions, definition of key terms and limitation of the study. The research examines the construct of SD in South Africa through research in the NSI within the public administration context. The introduction has shown that the importance of the aforementioned research topic cannot be overstated. The research now turns to reviewing literature on the construct of SD: the role of innovation in the South African economy.

CHAPTER TWO

SUSTAINABLE DEVELOPMENT: ROLE OF INNOVATION IN SOUTH AFRICA

2. SUSTAINABLE DEVELOPMENT

Having supplied the research background and objectives in Chapter One, this current chapter provides a theoretical perspective that serves as a 'reference dictionary' for the construct of SD within South African NSI.

The purpose of this chapter is to consider SD as an example of the intent (economic, social and environmental pillars) of research commercialisation. The literature will also enable policy makers to gauge the relative efforts across the various economic, social and environmental issues more effectively. The literature review has also been utilised in data analysis, drawing conclusion and recommendation.

2.1 INTRODUCTION

The chapter is structured as follows: section 2.2 considers elements of the construct of SD, namely: the social equity pillar, the sustainable structural transformation, the millennium development goals (MDGs), the economic pillar and the environmental pillar. Section 2.3 reviews the evolution of SD indicators. Section 2.4 reviews the frameworks for measuring (sustainable) development, exploring the IPAT equation, the Environmental Kuznets Curve (EKC) and ecological metabolism and structural change. Section 2.5 discusses the relevant theories that have direct and indirect impact on the construct of SD in South Africa through research in the NSI, namely: the modernisation theory, evolutionary/dependency theory, the human capital theory, the African renaissance theory and systems theory. Section 2.6 is a summary of the chapter. Having presented an introduction, the next section reviews elements of the construct of SD - the social equity pillar, the sustainable structural transformation, the MDGs, the economic and the environmental pillar.

2.2 THE CONSTRUCT OF SUSTAINABLE DEVELOPMENT

The concept of sustainable development has become a widely accepted standard, but still presents challenges in terms of its real meaning (Costa, Stoffel, Rodrigues & Oliveira 2010:1). From this research standpoint, SD can be applied in different knowledge areas which, according to scholars such as Kates, Parris and Leiserowitz (2005) and Wickenberg (2006) have widely been discussed as problematic and impossible from a scientific point of view. Also, the concept has evolved considerably. However, the problems intended to be addressed remain unsolved, creating the need for this research to add to the existing body of knowledge.

The term ‘sustainability’ is elusive, complex, broad, open-ended process and has different meanings with reference to economic, social and environmental policies depending on the specific reference literature or the context in which it is used (OECD, 2001a:4; Rammel & van den Bergh, 2003:122-123; Ásgeirsdóttir, 2004:18; Pierantoni, 2004:63; Holmberg & Samuelsson, 2006:8; Scott & Goug, 2006:93; Swanson, & Pintér, 2006:6), which can be attributed to the interconnections among sustainability factors and purposes (Schnurr & Holtz, 1998:34). However “to destroy is much easier than to build” (Eriksson, 2006:20). Therefore, this research literature attempts to operationalise what ‘sustainability’ means in the NSI context, bearing in mind that the quest for sustainability may be an elusive holy grail.

‘Sustainability’ is linked to durability and resilience (Munasinghe 2000; Winkler 2006) property of any system to maintain performance over time, lasting over time (Pezzey, 1992), with “now and in the future,” differing widely (Pierantoni, 2004:84; Kates et al., 2005:9). As pointed by Hřebík, Třebický and Gremlica (2006:1), “the concept of sustainable development can be seen as an idea, a philosophy, or political conviction or school of thought, based on a set of defined basic principles.” Sterling (2005:52) maintains that “the process of sustainable development or sustainable living is essentially one of learning, while the context of learning is essentially that of sustainability”. Nevertheless, Pierantoni (2004), Kates et al. (2005) Hřebíks (2006) among other SD scholars do not describe how such a context of sustainability learning can be created, leaving this research with a crippling issue. However, rather than continuously refining the definition of ‘sustainability’, the OECD reports elected to focus on exploring the components of SD.

In order for the concept of SD to be functional and applied in practice, clarifying the differences between ‘development’ and ‘growth’ is paramount. Flint (2007:3) differentiates between the two terms by explaining that growth is an increase in physical size through quantitative material increase. In contrast, development is the realisation of a fuller and greater potential- qualitative change, realisation of potentialities, and transition to a fuller or better state. Chaturvedi and Srinivas (2012:1641) highlight the importance of the concept of ‘inclusive growth’ out of the concern that raising inequalities can threaten sustainability of growth. According to Neumayer (2010:7), economic development is sustainable “if it does not decrease the capacity to provide non-declining per capita utility for infinity”. Economics, in this instance, refers to the study and allocation of scarce resources (Schumpeter, 1934; Lall & Petrobelli, 2002; Lal & Keen, 2005; Rodrik, 2007; Bell, 2007). From an NSI perspective resources are not ‘given’; rather they are created, applied and spread (Srininvas & Sutz, 2008:4). From an economic perspective, Heal (2007:20-21) describes SD as requiring “maintaining intact the value of a nation’s total capital stock over time". This research views the economic perspective as relevant to South Africa's NSI in utilising scarce resources and must, therefore, account for its choices (doing the right thing) and implementation (doing the thing right). Pasinetti (1973:12) views development as serving as a mirror of changing economic and social capacities, priorities and choices of a country. Furthermore, Robbins (1987:15) asserts that growth and development take place in an open system (complex and intricate), which is characterised by negative entropy, thereby systematically growing and developing. Negative entropy is important because entropy, in itself, occurs in closed systems with a steady decline in energy (Scott, 1981:109). Appendix 2 presents South Africa's economics statistical profiles, key tables by the OECD, (2013b). The Global 2011 report of HSBC by Ward (2011) ranked South Africa at position 30 in the year 2050, down two places from the current position and states:

> South Africa's outlook is constrained by the extremely low life expectancy related to the AIDS pandemic. At just 51 years, this knocks 1.5% points off the growth projections, relative to Turkey. One hopes that a solution to this disease is found over our time horizon, which should then serve to boost South Africa's growth rate significantly (Ward, 2011:17).

In this research context, in the search for the meaning of 'development', the option is to recombine the different definitions and dimensions of development to fit the different perspectives all together as part of a development mosaic and to reconstruct development as a synthesis of the various components and scholars.

In an attempt to define the construct of development, which is multi-dimensional, terms such as 'evolution' 'progress', 'economic growth', 'advancement', 'modernisation', 'capacitation' (capacities), 'improvement', and 'social change' have been used in literature, by authors such as Schumpeter (1947), Webster (1984), Harrison (1988), Fagerlind and Saha (1989), Bell (2007) and the European Union (EU) & The Young Foundation (2010:15). According to Molteberg and Bergstrom (2000:7), developmental studies "is research committed to improvement, addressing current, actual problems, focusing on solving them and` tend to be applied and action-policy oriented". The differing definitions of the concept development offer a *gestalt*; a total portrait from a particular angle and rival definitions offers a kaleidoscopic view into the collective mirror (Pieterse, 2010:8). Srininvas and Sutz (2008:9) observe that "development must be supported by a country's local strengths" in terms of both the production of knowledge and innovation. Sumner and Tribe (2008:11-12) perceive development as a process of structural societal change in diverse objectives and dimensions such as economic, social equity, political, legal and institutional structures, technology in various forms, the environment, religion, the arts and culture, human development and poverty eradication towards achieving freedom, entitlement and capability (Sen, 1999:41; Winkler, 2006:12; Sumner & Tribe, 2008:6).

According to Pieterse (2010:8-9) the concept of development has to do with stakeholders 'perceptions of development' implying intentional social change in accordance with societal objectives. Stakeholders' competing interests are inherently in conflict (Englund, 2006:357). As 'William I Thomas, cited in Winch (2004:322), put it "if men define situations as real, they are real in their consequences" Winch (2004:322) states that "too little and there is excessive force- 'whatever the group wants' too much and there is excessive conviction- 'my mind is made up'. Fight or flight extremes of human behaviour. The ideal is to create constructive contention where the attitude is: 'let's work together to figure this out'." In line with the Maslow's (1954) Hierarchy of Needs, the South African government should develop and implement NSI policies with respect to the stakeholders needs.

The World Summit on Sustainable Development (WSSD, 2002:1) articulated the Johannesburg Declaration on Sustainable Development that there is:

> A collective responsibility to advance and strengthen the interdependent and mutually reinforcing the three pillars of sustainable development—economic development, social development and environmental protection—at local, national, regional and global levels…

In 2003, the United Nations, European Commission (EC), International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD) and the World Bank jointly have attempted to put into operation the original definition of SD proposed by the Brundtland Commission. By including the definition of SD into law, South Africa formalised the definition of the concept by the National Environmental Management Act (NEMA), Act No. 107 of 1998; updated NEMA 2010 Environmental Impact Assessment (EIA) Regulations):

> Sustainable development means the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations.

According to Kates et al. (2005:11), the three major categories of what is to be sustained are: nature, life support systems, and community—as well as intermediate categories for each, such as earth, environment and cultures, as illustrated in Table 2.2-1.

Table 2.2-1: Elements of sustainable development

WHAT IS TO BE SUSTAINED:	FOR HOW LONG?	WHAT IS TO BE DEVELOPED:
NATURE Earth, Biodiversity, Ecosystems	25 years? "Now and in the future"? Forever?	**PEOPLE** Child survival Life expectancy Education Equity Equal opportunity
LIFE SUPPORT Ecosystem, services Resources, Environment **COMMUNITY** Cultures, Groups Places	**LINKED BY** Only Mostly But And Or	**ECONOMY** Wealth Productive sectors Consumption **SOCIETY** Institutions Social -capital States Regions

Source: Adapted from United States National Research Council (1999) and Kates et al (2005:11)

Table 2.2-1 illustrates that nature, life support, and community are the elements to be sustained for development of the people, economy and society. Besides its legal aspect, SD has clear philosophical, scientific, economic and political dimensions (Decleris, 2000; Kates et al., 2005:6). Neumayer (2010:3) is of the view that the 'what' should be sustained is just as important as is 'how' to sustain. The social, ecological/environmental and economic subsystems can also be viewed as nested within each other and forming a complex human-environment system as illustrated in Figure 2.2-1.

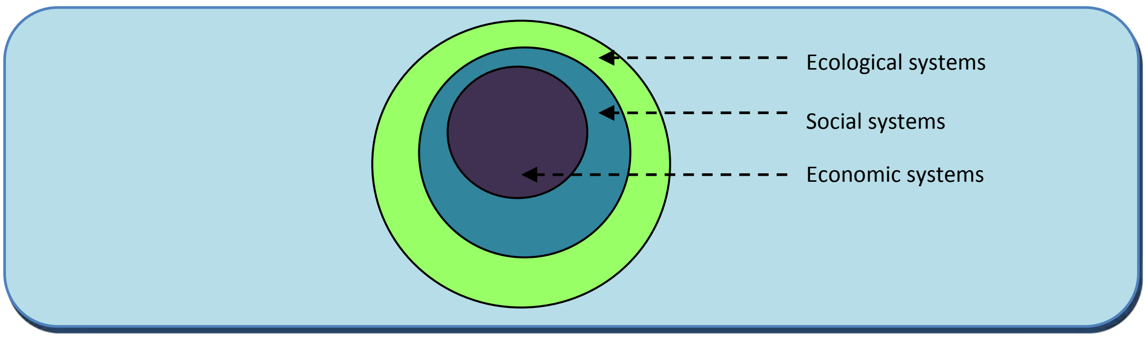


Figure 2.2-1: Ecological, social and economic subsystems
Source: Adapted from Lal and Keen (2005:3)

In view of the three aforementioned pillars, development according to Schnurr and Holtz (1998:34), is essentially about the effective integration of social, economic and ecological considerations at all scales from local to global, over the long haul. According to UNCTAD

(2009:9), a country should not focus entirely on the economic pillar and rely on "trickle down" effects to provide for the attainment the social and environmental pillars. However, in practical applications, Spangenberg (2002:295–309) argues that the three pillar-focused approaches have suffered from a tendency to facilitate continued separation of social, economic and ecological analyses. In attempting to integrate the three pillars, Figure 2.2-2 presents a framework where the World Economic Forum (WEF, 2013:62) index for measuring competitiveness, the Global Competitiveness Index (GCI), is adjusted by factors that encompass social and environmental sustainability.

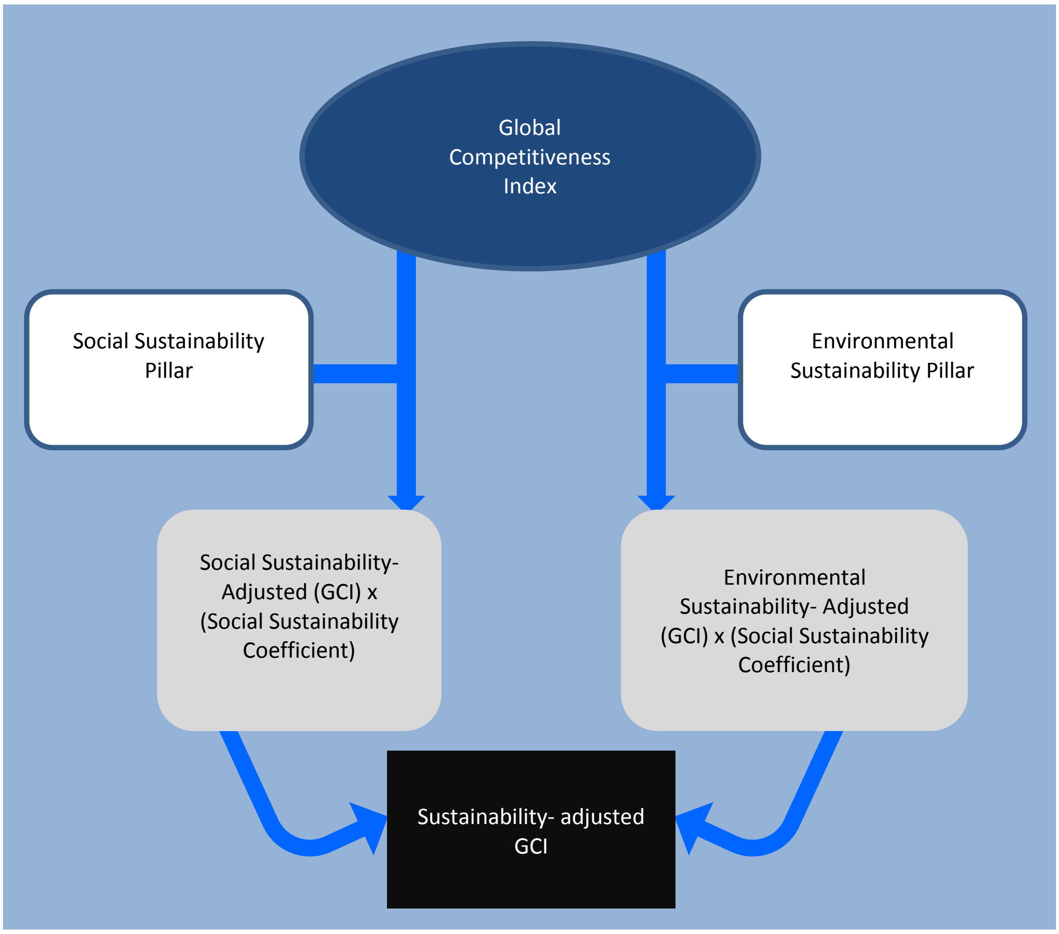


Figure 2.2-2: The structure of the sustainability-adjusted GCI
Source: World Economic Forum (2013:62)

Figure 2.2-2 aims to create a common ground to develop policies that balance economic prosperity with social inclusion and environmental stewardship and highlights the central position of competitiveness as the key driver of sustained prosperity. Table 2.2-2 presents 12 pillars of the GCI collated from the WEF (2013:4-9).

Table 2.2-2: The 12 pillars of Global Competitiveness Index (GCI)

	PILLARS	BRIEF DESCRIPTION OF THE PILLAR
1.	Institutions	The quality of institutions has a strong bearing on competitiveness and growth (Easterly & Levine, 1997; Rodrik, Subramanian & Trebbi, 2002). Government attitudes toward markets and freedoms and the efficiency of its operations are also very important: excessive bureaucracy and red tape (De Soto & Abbot, 1990) overregulation, corruption, dishonesty in dealing with public contracts, lack of transparency and trustworthiness, inability to provide appropriate services for the business sector, and political dependence of the judicial system impose significant economic costs to businesses and slow the process of economic development.
2.	Infrastructure	Well-developed transport (quality roads, railroads, ports, and air transport), electricity supplies and solid and extensive telecommunications network allows for a rapid and free flow of information, determining the location of economic activity and the kinds of activities or sectors that can develop within a country. Well-developed infrastructure reduces the effect of distance between regions, integrating the national market impact economic growth and reduces income inequalities and poverty in a variety of ways (Aschauer, 1989; Gramlich, 1994; Easterly & Levine, 1997).
3.	Macroeconomic environment	Stability of the macroeconomic environment is important for business and, therefore, is significant for the overall competitiveness of a country (Fischer, 1993). The government cannot provide services efficiently if it has to make high-interest payments on its past debts. Running fiscal deficits limits the government's future ability to react to business cycles. Firms cannot operate efficiently when inflation rates are out of hand.
4.	Health and primary education	Poor health leads to significant costs to business absent or operate at lower levels of efficiency. Investment in the provision of health services is thus critical for clear economic, as well as moral, considerations (Sachs, 2001). Basic education increases the efficiency of each individual worker. Macroeconomic policies can have large consequences for human development. Cutting social spending to reduce public debt can have long-term effects such as reduces aggregate demand, which, coupled with high income inequality, makes it challenging to revive the economy (United Nations Development Programme UNDP, 2013:22).
5.	Higher education and training	Quality higher education is crucial for economies that want to move up the value chain beyond simple production processes and products (Schultz, 1961:1981; Lucas, 1988). The pillar measures secondary and tertiary enrolment rates as well as the quality of education as evaluated by business leaders. The extent of staff training is also taken into consideration.
6.	Goods market efficiency	Healthy market competition, both domestic and foreign, is important in driving market efficiency, and thus business productivity, requires a minimum of government intervention, competitiveness is hindered by distortionary or burdensome taxes and by restrictive and discriminatory rules FDI—which limit foreign ownership—as well as on international trade.
7.	Labour market efficiency	Labour markets must therefore have the flexibility to shift workers from one economic activity to another rapidly and at low cost, and to allow for wage fluctuations without much social disruption (Almeida & Carneiro, 2009; Amin, 2009; Kaplan, 2009). Efficient labour markets must also ensure clear strong

Pillars		Brief description of the pillar
		incentives for employees and efforts to promote meritocracy at the workplace and must provide equity in the business environment.
8.	Financial market development	Efficient and sophisticated financial markets that can make capital available for private-sector investment from such sources as loans from a sound banking sector, well-regulated securities exchanges, venture capital, and other financial products, trustworthy and transparent are critical components.
9.	Technological readiness	ICT access and usage as key enablers of countries' overall technological readiness pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, for efficiency and enabling innovation for competitiveness (Aghion & Howitt, 1992; Barro & Sala-i-Martín, 1992).
10.	Market size	Large markets allow firms to exploit economies of scale, globalisation, and international markets have become a substitute for domestic markets, exports, trade openness is associated with growth, and trade has a positive effect on growth, especially for countries with small domestic markets (Frenkel & Romer, 1999; Sachs, 2001; Rodrik et al., 2002).
11.	Business sophistication	The quality of a country's business networks and supporting industries, as measured by the quantity and quality of interaction, sector are interconnected in geographically into clusters. Individual firms' advanced operations and strategies (branding, marketing, distribution and production) spill over into the economy.
12.	Innovation	Standards of living largely enhanced by innovation, requires sufficient investment in R&D, by private sector; the presence of high-quality research institutions collaboration between universities and industry; and the protection of IP.

Source: Collated from World Economic Forum (2013:4-9)

The 12 pillars of competitiveness are not independent, but reinforce each other; weakness in one area has a negative impact in others. For example, a strong innovation capacity (pillar 12) will be difficult to achieve without a healthy, well-educated and trained workforce (pillars 4 and 5). The Europe 2020 Strategy has also included the social and environmental sustainability dimensions for smart, inclusive and sustainable growth, which puts forward three mutually reinforcing priorities (European Commission (EC), 2010). The three priorities include 75 % of the population aged 20-64 should be employed, a 3% of the European Union's (EU's) gross domestic product (GDP should be invested in R&D, and a "20/20/20" climate/energy targets should be met (EC, 2010:3). Similarly, in May 2011, OECD (2011a) unveiled a new, interactive index 'the Better Life Initiative' that goes beyond traditional GDP numbers based on 11 dimensions, namely: (i) housing, (ii) income, (iii) jobs, (iv) community, (v) education, (vi) environment, (vii) governance, (viii) health, (ix) life satisfaction, (x) safety, (xi) work-life balance (OECD, 2011a). UNDP (2013) has also included the concepts of environmental sustainability and social equity in the UNDP human development assessment shown in Table 2.2-3.

Table 2.2-3: Human development statistical indices

HUMAN DEVELOPMENT STATISTICAL INDICES	
Human development indices 1. Human Development Index and its components 2. Human Development Index trends, 1980–2012 3. Inequality-adjusted Human Development Index Experimental indices 4. Gender Inequality Index 5. Multidimensional Poverty Index	Human development indicators 6. Command over resources 7. Health 8. Education 9. Social integration 10. International trade flows of goods and services 11. International capital flows and migration 12. Innovation and technology 13. Environment 14. Population trends

Source: collated from UNDP (2013:139)

Table 2.2-3 depicts composite human development indices (HDI) and corresponding components, whereby countries are ranked according to HDI value. The historical international milestones on SD are outlined in Table 2.2-4. A milestone is a significant event in the policy, usually completion of a major deliverable (Archibald, 1988:65; Project Management Institute PMI, 2008:165).

Table 2.2-4: Historical international milestones on sustainable development

YEAR	MILESTONE…	… ALSO KNOWN AS…	BRIEF DESCRIPTION
1972	UN Conference on the Human Environment	Stockholm conference	Introduction of environmental challenges in the political development discourse
1987	"Our common future" - WCED	Brundtland report	Introduction of a definition of sustainable development linking environment with economic and social development
1992	UN Conference on Environment and Development in Rio de Janeiro	Earth Summit	Adoption by 178 governments of 5 main documents: • Rio declaration on environment and development. • Agenda 21 on SD, composed by three "pillars" – economic, social, and environmental.
2000	UN MDGs Summit	MDGs Summit	Adoption of a global action plan to achieve the eight anti-poverty goals by the 2015 target
2002	Mexico	Monterrey	Monterrey Consensus
2002	WCED in Johannesburg	World Summit	Adoption of Johannesburg Declaration and Implementation plan, focusing on poverty reduction by reaffirming the principles of Agenda 21 and the Rio principles.
2005	Kyoto Protocol entered into force	Kyoto	The Kyoto Protocol, Japan, on 11 December 1997 (UNFCCC-COP3) and entered into force on 16 February 2005 and adopted at COP7 "Marrakesh Accords" in 2001.

Source: Adapted from the OECD (2005a:18-19) and Hřebík, Třebický and Gremlica (2006:57)

Table 2.2-4 illustrates the critical milestones made especially with regard to environmental and social pillars. Furthermore, Table 2.2-5 provides an overview of the evolution of the concept of SD adapted from (Hřebík et al., 2006:57).

Table 2.2-5: An overview of the evolution of the concept of sustainable development

OVERVIEW OF THE EVOLUTION OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT
Historically and internationally, the main milestones of the evolution of SD are: • 1972: The first definition of 'sustainable development' published in The Ecologist. • 1972: The first report by The Club of Rome ('Limits to Growth') documented that the current pattern of industrial society was not sustainable in the long term. • 1980: A global environment conservation strategy (IUCN, UNEP, and WWF) defined the close interconnection between economic progress and environment conservation. • 1984: World watch Institute, Washington D.C., published its first yearbook 'The State of the World – Toward a Sustainable Society'. • 1984: International Conference on Environment and Economics (OECD) – Concluded that environment and economics should be mutually reinforcing. Helped shape Our Common Future (see below). • 1987: World Environment Commission published its report 'Our Common Future' and the term SD became a common term on the global community's agenda. • 1991: IUCN, UNEP, and WWF publish the 'Caring for the Earth – A Strategy for SD'. • 1992: UNCED, nicknamed 'Earth Summit' in Rio de Janeiro, Brazil, dealing with the global problems of humanity with a record-breaking participation of major countries of the world, accepted the 'Declaration on the Environment and Development,' which contains 27 principles of SD and a detailed instruction for its implementation: the Agenda 21. • 1992: The Committee for Sustainable Development (CSD) established under the UN with the mission to implement the UNCED documents and monitor the enforcement. • 1995: The CSD set up a group of experts in order to develop and evaluate SD indicators. The work has resulted in 134 SD indicators and a methodology for use. • 1997: The United Nations General Assembly (UNGASS), dedicated to the fifth anniversary of the UNCED, stated insufficient progress in implementing SD world-wide. • 2001: OECD recognises that SD is an overarching worldwide phenomenon. • 2001: Council of Europe Meeting in Gothenburg; European Union SD Strategy accepted. • 2002: The Rio + 10 Conference in Johannesburg at the tenth anniversary of the UNCED. • 2005: The EC presented its assessment report on the current results of the EU SD Strategy.

Source: Adapted from Hřebík et al., (2006:57)

2.2.1 Social Equity Pillar

From this research perspective, social challenges facing South Africa require multi-stakeholders participation, the ability to span boundaries both horizontally and vertically across various NSI hierarchies. The SA Diagnostic Report (NPC 2011a:8) and SA NPC (2011b:8) cogently and urgently acknowledge that persistence of "widespread poverty and extreme inequality…implies that different units possess different amounts of this attribute. The units can be individuals, social groups, communities, nations; the attributes include such things as income, wealth, status, knowledge, and power". Sutz (2014:xx-xxi) relates innovation to inequality, as inequality also influences innovation. In this research context, innovation efforts should be orientated in a direction that diminishes inequality. Implementing the poverty mission in South Africa's NSI will require the strengthening of the network components and framework conditions, and the collaboration of the various network players as well as the additional construction of NSI policy mix mandates.

The Diagnostic Report (NPC 2011a) provides the basis for the NPC's plan by identifying the main challenges confronting South Africa and examining the underlying causes which, in summary, include: (i) too few South Africans are employed; (ii) the quality of education for poor black South Africans is substandard; (iii) poorly located and inadequate infrastructure limits social inclusion and faster economic growth; (iv) South Africa's growth path is highly resource-intensive and hence unsustainable; (v) spatial challenges continue to marginalise the poor; (vi) the ailing public health system confronts a massive disease burden; (v) the performance of the public service is uneven; (vi) corruption undermines state legitimacy and service delivery; and (vii) South Africa remains a divided society (NPC Diagnostic Report, 2011a:1-29; NPC, 2011b:3).

From this research perspective, legitimacy of the South African government is an important issue in tacking SD challenges, which has resulted from research commercialisation in the NSI. The increasing 'distance' among the NSI actors, which contributes to a 'scattered' NSI framework (partly emerging as unintended as well as those intended and others partly autonomous, such as globalisation, financial crisis and other closely related market-based revolutions) raises questions about the effectiveness, legitimacy and responsiveness of the main NSI actor, particularly the South African government's role in strengthening the lost or weak interactions. In Goodwin's (2011:63) terminology:

> The legitimacy of institutions (global, national and local) and the legitimacy of the solutions they generate through social innovation come not simply from the process of deliberation but explicitly from the institutional commitment and openness to difference and from their ability to reflect upon their own objectives, strategies and institutional form in the light of that commitment.

The second of the five TYIP SA DST (2008:5) key principles states that "Competitive advantage: the government should invest in areas of the highest socioeconomic return that is Grand Challenges". This research argues that dealing with socioeconomic challenges facing South Africa will require priority setting and active NSI actors' involvement. Consequently, innovation will have to be regarded as a core objective in seeking to develop sustainable industrial base (Evans & Rauch, 1999; Wade, 2004a; Bekkers et al., 2011b; Chavula & Konde, 2011). Some the major challenges facing South Africa are unemployment and poverty, with about 40% of South African households still living below a poverty line- about R480 per person per month. Poverty and unemployment are closely linked, with the most undesirable outcomes of unemployment being the rise in crime and substance abuse in South Africa (Dinokeng Scenarios, 2009).

The South African government has embarked on the New Growth Path (NGP) Framework by EDD (2010), which centres on a massive investment in five key infrastructure areas namely: (i) energy (ii) transport (iii) communication (iii) water and (vi) housing to create jobs in construction, operation and maintenance of infrastructure, as a critical driver of dealing with the sluggish economic growth, poverty and joblessness. In this research context, an effective NSI framework, which nurtures research, research commercialisation and innovation, will be pivotal in realising the NGP (EDD, 2010).

The concept of Social innovation, or innovation for development, which is 'manifold' (Harayama & Nitta, 2011:13) and 'boundary spanning' (Goodwin, 2011:59) across the NSI is closely related to the social pillar and has emerged in last decade both in international and local literature. Social innovation relates to innovation for addressing social issues, such as education and health, issues of inequality and inclusion (Lafferty, Ruud & Larsen, 2005; Leadbeater, 2008:16), which carry a public-good nature. The WEF (2013:59) defines social sustainability as:

> The institutions, policies, and factors that enable all members of society to experience the best possible health, participation, and security; and that maximize their potential to contribute to and benefit from the economic prosperity of the country in which they live.

This research defines social innovation according to the European Union and The Young Foundation (2010:17-18), definition:

> Innovations that are social both in their ends and in their means…as new ideas (products, services and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations. In other words they are innovations that are both good for society and enhance society's capacity to act.

However analysis of how innovation for development is to be undertaken, especially in the South African context, is lacking. Innovation is a social activity, a process of collectively combining primarily existing ideas, which entails connecting parallel domains of human expertise and value creation (Breznitz, Ketokivi & Rouvinen, 2011:73; Harayama & Nitta, 2011:16; OECD, 2011a:17). South Africa's NSI is characterised by systemic social inequality, that of unequal development (Abrahams & Pogue, 2010:23), where social well-being is a goal and not a consequence (OECD, 2010a:133-140; OECD, 2011b:17). The research perceives the achievement of SD objectives in South Africa as dependant on both technological and social innovation coupled with organisational and institutional reforms. This research further argues that social innovation can be used to address the wicked challenges and grand challenges facing South Africa. The 'wicked challenges' (Bekkers et al., 2011b:212) facing African societies are coined with a 'double risk' factor, namely: sustainability risks associated with production (for example, pollution, migrant labour) as described by Beck (1992) and the risks and vulnerabilities associated with poverty (Le Grange, 2003; Fakir, 2002). The wicked challenges facing South Africa include the fight against crime, social unrest, unemployment, political instability, traffic congestion, water, sanitation and electricity management and provision, air pollution, economic and social decline, and inequality (Bekkers et al., 2011b:212). A range of other challenges facing South Africa include climate change, waste pollution, deforestation, desertification and degradation of freshwater resources, to the loss of biodiversity (Fischer-Kowalski & Haberl, 2007).

A review of the NPC (2011a; 2011b) documents indicate that the South African system is sensing powerful demand signals to tackle the wicked challenges, which the government has articulated as the crisis of poverty and inequality; indeed it has done so repeatedly. This research argues that tackling the 'wicked challenges' will require coordination and integration of various interfaces of the South African policy mix. Archibald (1988:66) identifies three types of policy interfaces, namely: (a) personal or people interface (b) organisational interfaces and (c) system interfaces. This research further argues that an innovative public sector is required to create a legitimate NSI sector that is able to address the various 'wicked' societal challenges. According to Bekkers et al. (2011a:5), how the governments handle and respond to societal challenges not only affect effectiveness, but also influence governments' legitimacy.

In South Africa, the backlog for social change is immense (NPC, 2011a:22), with capacity within the public service remaining constrained (Van den Heever, 2011:6). This research views the South African government as central in providing resources in financial terms, policy- and strategy-development processes and leveraging positive social change. The South African social grant registries contain information on about 17 million or more past beneficiaries who, for one reason or another, were severely disadvantaged. Opportunities to link social innovation in order to achieve complementary and multiplier effects in South Africa include social security and labour activation, education and health (Van den Heever, 2011:7). However, such linkages are limited and accompanied by insufficient delivery platforms. Nevertheless, some South African individual NGOs have succeeded in crafting niche functions in the development arena, thereby providing potential platform (or at least a template) for system-wide functions (SA DST Ministerial Review Committee, 2012:137), such as lmpumelelo Social Innovations Centre; lnyathelo, the South African Institute for Advancement and The Green House which recreates the city ecologically, socially and economically in sustainable ways. Prolinnova (Promoting Local Innovations) is a global organisation supporting and disseminating farmer innovation capacities in partnership with provincial departments of agriculture and the Agricultural Research Centres (ARC).

The basic thrust of the South African government's Medium-Term Strategic Framework (MTSF) 2009-2014 is to improve and identify opportunities for new areas of growth and economic participation through: (i) more inclusive economic growth, decent work and sustainable livelihoods; (ii) economic and social infrastructure; (iii) rural development, food security and land reform; (iv) access to quality education; (v) improved health care; (vi) curbing crime and corruption; and (vii) cohesive and sustainable communities. South Africa's social sustainability is undermined by high income inequality and youth unemployment. In addition, the country has not yet achieved universal access to sanitation. On a more positive note, the share of the population in vulnerable employment is relatively low and social mobility is somewhat better than it is in many other countries at a similar stage of development (WEF, 2013:70).

The South African Government's MTSF 2009-2014 (2009:4) further posited that a number of new opportunities as well as some serious new risks could arise in the context of possible scenarios such as: (i) '*Not yet Uhuru*', which depicts a government committed to accelerating economic growth through optimising conditions for private investment, but which struggles to achieve its goals in the face of slow growth and minimal sharing of benefits, deteriorating global conditions and severe ecological challenges; (ii) '*Nkalakatha';* which depicts a more cohesive society as a result of government articulating a compelling national vision and fostering partnerships, while playing a more central role in the economy, prioritising poverty reduction and skills enhancement; (iii) '*Muvhango*', which depicts a government that battles to govern well despite an initial resurgence of the economy and positive world conditions, because of poor planning, lack of coordination, slow policy implementation as well as internecine and debilitating warfare within the party-political arena. This research views the '*Nkalakatha*' as offering new opportunities for achieving the MTSF 2009-2014 objectives.

2.2.2 Sustainable Structural Transformation

One of the main challenges facing LDC, including South Africa, is the promotion of structural transformation. In this research context, sustainable structural transformation (SST) involves the adoption of deliberate, concerted and proactive policies to promote structural transformation (UNCTAD, 2012:5:26; 66; 131). Consequently, the research argues that there is a need for a strategy of SST in South Africa for sustainable competitiveness as supported by the United Nations Conference on Trade and Development, (UNCTAD 2012). The WEF (2013:61) defines sustainable competitiveness as the set of institutions, policies and factors that make a nation remain productive over the longer term, while ensuring social and environmental sustainability. The Johannesburg Declaration on Sustainable Development (2002) by the WSSD explicitly recognised the need to delink economic growth and environmental degradation. In South Africa, this kind of delinking will require implementing SST. Kuznets (1971:348) notes that structural changes ". . . are required, without which modern economic growth would be impossible".

The UNCTAD (2012:5:26-131) examines the concept of sustainable structural transformation, using the constructs of 'relative decoupling' and 'absolute decoupling'. The OECD (2001b) rhetorically defined decoupling as the process of breaking the links between environmental 'bads' and economic 'goods'. The UNCTAD (2012:5:6:73) referring to the African region, argues that the focus of African policymakers should be on 'relative decoupling' rather than absolute decoupling, because the African region has very low per capita resource use compared with the global average and is also not a major polluter. Even though the African region needs more policy space for SST, assuming that the African economies grow at least by 7 per cent per annum, the GDP will be seven times higher in 2050. This growth implies that the region should focus on improving resource productivity and seeking to mitigate the environmental impacts of resource use (UNCTAD, 2012:5:73).

The United Nations Environment Programme (UNEP 2011a) has further developed the concept of decoupling by distinguishing two separate components of decoupling: resource decoupling and impact decoupling. Resource decoupling can be achieved by increasing resource productivity or efficiency (GDP per resource use) or, conversely, by decreasing resource intensity (resource use per GDP). Lafferty et al. (2005) also explore the concept of decoupling and include the term 'recoupling' in terms of four "normative modes" for the integration of environmental concerns and innovation policy illustrated in Table 2.2.2-1.

Table 2.2.2-1: Normative modes for the integration of environmental concerns and innovation

Integration steered by government actors			
		Process norms	Substantive norms
Goal of integration	Decoupling	*Environmental protection:*	*Ecological communalism:*
		Major emphasis on end-of-pipe regulation and prevention of pollution.	Major emphasis on limiting growth. Reliance on self-sustaining lifestyles and communal values.
	Recoupling	*Ecological modernisation:*	*Sustainable development:*
		Major emphasis on improving eco-efficiency of existing sectoral practices through "win-win" solutions. Plays down zero-sum conflicts of interests and trade-offs.	Major emphasis on achieving overall eco-effectiveness in a global context. Assigns "principled priority" to maintaining and enhancing natural life-support systems.

Source: Lafferty, Ruud and Larsen (2005:228)

Decoupling to alter practices into more sustainable practices requires "recoupling" environmental protective measures and economic growth patterns (Lafferty et al., 2005:222). The aforementioned normative-functional framework highlights the particular challenge of integrating the dual goals of SD and innovation for South Africa. The concept of SST is applied in this research context as not simply related to the emergence of specific green sectors but rather to the greening of the entire economy through relative rather than absolute decoupling. Ocampo (2011:11) for instance, notes that green growth should best be comprehended as a process of structural change, for the formulation of least developed countries (LDCs) SD strategies.

The UNCTAD (2012:6:32) defines the 'green' concept of SST as a way to operationalise (to put into operation) the concept of the green economy in the context of SD and poverty eradication. The UNEP (2011b:21) defines a green economy as one which is "low-carbon, resource-efficient and socially inclusive, or… one that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities". Risk in this research context is defined according to Hillson (2009:6) as "uncertainty that matters". The research argues that the concept of green growth should not be viewed as replacements for the construct of SD, rather as stated by (UNEP, 2011b:31) "a growing recognition that achieving sustainability rests almost entirely on getting the economy right". The first sign that the green economy was being prioritised by the South African government was the approval by Cabinet of a number of key sustainability supportive policies. The policies included the MTSF of 2009–2014, the TYIP of 2008, the revised Industrial Policy Action Plan for 2010/11–2012/13 (IPAP2), the revised Integrated Resource Plan (IRP2) and the NGP by EDD (2010).

2.2.3 Millennium Development Goals

During the Millennium Summit in September 2000, world leaders passed the Millennium Declaration, which formally established the UNDP Millennium Development Goals (MDGs). The MDGs have the advantage of (i) offering a comprehensive and multi-dimensional development framework, (ii) a political mandate agreed by the leaders of all UN member states, and (iii) setting clear quantifiable targets to be achieved in all countries by 2015 (UNDP MDGs, 2010).

The eight MDGs serve as the new framework for SD by setting social equity goals and targets that aim at contributing to economic development while ensuring environmental sustainability (NEPAD, 2010:26). The progress chart for selected MDG targets in Northern Africa and sub-Saharan Africa is depicted in Table 2.2.3-1.

Table 2.2.3-1: Progress chart Africa MDGs of selected targets and indicators (2009)

GOAL	OBJECTIVE	INDICATORS/TARGETS FOR 2015	NORTHERN AFRICA	SUB-SAHARAN
1	Eradicate extreme poverty and hunger	Reduce extreme poverty by half	Low poverty	Very high poverty
		Productive and decent employment	Large deficit in decent work	Very large deficit in decent work
		Reduce hunger by half	Low hunger	Very high hunger
2	Universal primary education	Universal primary schooling	High enrolment	Low enrolment
3	Promote gender equality and empower women	Equal girls' enrolment in school	Close to parity	Close to parity
		Women's share of paid employment	Low share	Low share
		Women represented in parliaments	Very low	Low representation
4	Reduce child mortality	Reduce mortality of under five-year-olds by two thirds	Low mortality	Very high mortality
		Measles immunisation	High coverage	Moderate coverage
5	Improve maternal health	Reduce maternal mortality by three-quarters	Moderate mortality	Very high mortality
		Access to reproductive health	Moderate	Low access
6	Combat HIV/AIDS, malaria diseases	Halt and reverse spread of HIV/AIDS	Low	High prevalence
		Halt and reverse tuberculosis	Low mortality	High mortality
7	Ensure environmental sustainability	Reverse loss of forests	Low coverage	Medium coverage
		Halve proportion without improved drinking water	High coverage	Low coverage
		Halve proportion without sanitation	Moderate coverage	Very low coverage
		Improve lives of slum dwellers		
8	Development	The number of Internet users	Moderate	Very low usage

Source: NEPAD (2010:26)

The first MDG of halving the proportion of people living on less than \$1.25 a day relative to 1990 has been met three years before the target date. However, an estimated (between 2002 and 2011) 1.57 billion people, or more than 30% of the population of the 104 countries studied for the UNDP (2013) Report, live in multidimensional poverty, a measure of both the number and the intensity of overlapping human deprivations in health, education and standard of living. Sub-Saharan Africa has the most inequality in health, and South Asia in education (UNDP, 2013:14).

2.2.4 Economic Pillar

South Africa has not been spared from deep global economic slowdown that has slumped demand for export products along with falling commodity prices, significant reductions in foreign investment and a more general liquidity shortage. In the last decade, variables such as labour strike, legal action by interest groups, trade embargoes and material shortages have had a negative impact on South Africa's economy. In a difficult global economic environment, South Africa should put into place strong fundamentals for economic competitiveness, growth and development.

South Africa was ranked 53rd during the 2013 index. Table 2.2-8 shows improvements and slippages in respect of the WEF's 12 pillars. The indicators raise various issues as South Africa aspires to become an innovation and knowledge-driven economy. The 2013 Budget Speech by the Minister of Finance indicated that South Africa's economy has expanded over the past three years, but the rate of growth has steadily declined from 3.5 per cent of GDP in 2011 to a projected 2.1 per cent in 2013. This trend reflects a confluence of unfavourable global and domestic circumstances.

Table 2.2.4-1 indicates that the biggest decline took place in the following pillars over the past three years: (i) Macroeconomic Environment, from 43rd down to 95th place; (ii) Higher Education, from 75th down to 89th place; (iii) Labour Market Efficiency, from 97th down to 116th place. Low scores for the diversion of public funds (99th), the perceived wastefulness of government spending (79th), and a more general lack of public trust in politicians (98th) remain worrisome, while security continues to be a major area of concern for doing business (at 109th). Building a skilled labour force and creating sufficient employment also present considerable challenges. The health of the workforce is ranked 133rd out of 148 economies—the result of high rates of communicable diseases and poor health indicators, more generally. The quality of the educational system is very poor (146th), with low primary and tertiary enrolment rates. Labour market efficiency is poor (116th), hiring and firing practices are extremely rigid (147th), companies cannot set wages flexibly (144th) and significant tensions in labour-employer relations exist (148th). Regarding employment, skills, health, education, the WEF (2013:43) observes that building a skilled labour force and creating sufficient employment also pose "considerable challenges" for South Africa. This research shares similar views with the WEF (2013:43) that raising educational standards and making the labour market more efficient will be critical in view of South Africa's over 20% high unemployment rate, of which youth unemployment is estimated at being close to 50%.

Table 2.2.4-1: South African 2013 index 12 pillars

MEASURE	2012 RANKING (OUT OF 139 COUNTRIES)	2013 RANKING (OUT OF 142 COUNTRIES)	RANKING (OUT OF 148 COUNTRIES)	SHIFT
SA overall Ranking	54	50	53	↓
Basic Requirements overall score	79	85	95	↓
Institutions	47	46	41	↓
Infrastructure	63	62	66	↓
Macro-economics	43	55	95	↓
Health and Education	129	131	135	↓
Efficiency Enhancers overall score	42	38	34	↑
Higher Education	75	73	89	↓
Goods Market Efficiency	40	32	28	↑
Labour Market Development	9	4	3	↑
Technological Readiness	76	76	62	↑
Market size	25	25	25	→
Innovation and Sophistication	43	39	37	↑
Business Sophistication	38	39	35	↑
Innovation	44	41	39	↑

Source: Collated from World Economic Forum, (2013:324)

South Africa's strong ties to advanced economies, notably the euro area, make it more vulnerable to their economic slowdown and likely have contributed to the deterioration of fiscal indicators: its performance in the macroeconomic environment has dropped sharply from 69th to 95th (WEF, 2013:43). However, according to Metcalfe and Ramlogan (2006:375) national economic development activities do not expand at the same proportional rate "von Neumann style". Yet, this research fundamentally views (sustainable) development as requiring the application and commercialisation of knowledge into innovation. Scholars such as Katz (1987), Bell and Pavitt (1993), Lundvall, (1992), Metcalfe (1995), Lall and Teubal (1998), Mowery, Nelson & Ziedonis (2001) and Edquist, (2005) explicitly highlight the linking innovation to economic development as a process of learning, varied by and dependent on the particular development environment. South Africa has experienced a paradox between strong innovation capabilities, but poor economic performance (SA DST Ministerial Review Committee, 2012:81). The aforementioned paradox implies that there are structural reasons the South African economy and the labour-creating ability appear to be stuck within the NSI framework conditions, termed the 'binding constraints', that lie beyond the realm of innovation policy formulation undertaken by the DST. In accordance with the

National Treasury Republic of South Africa (2013:4) it is acknowledged that to address constraints in key economic sectors government will require cooperation and collaboration between the private sector and other NSI actors. Key required initiatives in South Africa include: (i) addressing gaps in the social wage and working conditions by developing an agreement for resolution of labour disputes in the mining sector; (ii) investing in freight capacity to help alleviate supply bottlenecks; (iii) improving pricing, efficiency and competitiveness at local ports; (iv) developing the clothing and textiles competitiveness programme; (v) assisting manufacturers to modernise production processes to meet international standards; (vii) implementing tariff protection in response to unfair trade practices by importing firms and exporting countries; (viii) supporting the motor industry through grant-based incentives and tax offsets; (ix) introducing designated products for local production as part of government procurement policy and; (x) broadening access to finance and support services for small (particularly black-owned) businesses (National Treasury Republic of South Africa, 2013).

2.2.5 Environmental Pillar

In this research context, the concept of SD will require a strong consensus with regard to EIA. The mandate for policy integration for SD with respect to the environmental pillar can be traced to the "Brundtland Report", Chapter 12 of Our Common Future which states:

> *The ability to choose policy paths that are sustainable requires that the ecological dimensions of policy be considered at the same time as the economic, trade, energy, agricultural, industrial, and other dimensions – on the same agendas and in the same national and international institutions. That is the chief institutional challenge of the 1990s* (WCED, 1987:313).

The concept of EIA is defined as:

> A process for the orderly and systematic evaluation of a proposal includes its alternatives and objectives and its effect on the environment including the mitigation and management of those effects. The process extends from the initial concept of the proposal through implementation to completion, and where appropriate, decommissioning" (Australian/New Zealand Standard ASNZS 4360:2009:3).

Roughly until the mid-1990s, environmental policies, institutions and legislation were built around traditional environmental sectors (water, air, waste, soil). However, as from the mid-1990s, the approach was noted to be entirely ineffective and other policy concepts have been added and broadened (Lafferty et al., 2005:257). The relationship between innovation and the environment has for last decade received specific treatment in the international literature, for example by the EU Commission and the OECD. Although some progress has been made with regard to the environmental pillar and policy the conclusion of the (International Institute of European Environmental Policy (IEEP, 2001:16) still stands, which states that:

Despite a progressive commitment to environmental integration, relatively little attention has been given to defining the concept. There is a confusing variety of methods for taking more account of environmental factors in the development of sectoral policies.

The fourth of SA DST TYIP (2008) Grand Challenges is the 'Global-Change Science with a focus on Climate Change'. From an environmental point of view, South Africa's performance is weakened mainly by increasing carbon dioxide (CO_2) emissions and strained water and fish stock resources (WEF, 2013:70). Addressing the fourth Grand Challenge implies the incorporation of environmental objectives with the economic and social pillars. Accordingly, the two main environmental issues affecting South Africa are development of policy relevance and measuring indicators. Lafferty et al. (2005:259) note that environmental policy integration with the non-environmental policy sectors is critical in all stages of policymaking. According to Lafferty et al. (2005:255) efficient and effective integration can be enhanced through a change in economic behaviour, a shift from traditional environmental approaches and implementation of new innovation policy instruments (separated worlds) because as is, each (environmental policy and the non-environmental policy) offer isolated measures (Lafferty et al., 2005:255). The complementary observation is illustrated in Figure 2.2.5-1.

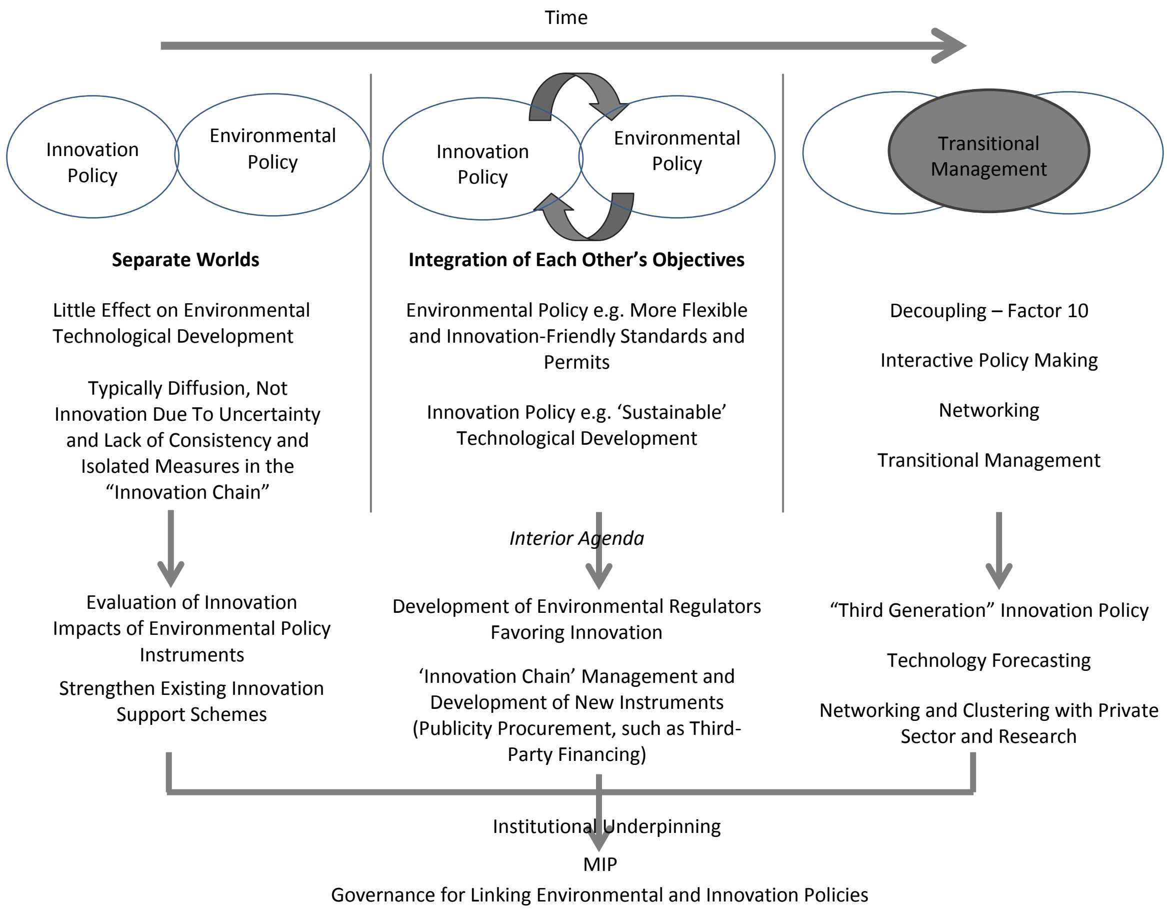


Figure 2.2.5-1: Environmental and innovation policy perspectives
Source: Lafferty, Ruud and Larsen (2005:254)

Figure 2.2.5-1indicates that the traditional environmental and innovation policy instruments offer isolated measures, which has little effect and have been viewed as a barrier to innovation (Lafferty et al., 2005:255). The South African Department of Environmental Affairs and Tourism (DEAT) (2008;2010) has developed 126 environmental indicators with only 53 (42 per cent) being classified as level 1 indicators that are suitable for use. It may be argued that South Africa can adopt indicators such as the System of National Accounts (SNA) for strengthening and assessing institutional capacities to achieve set targets; revising indicators, legal, regulatory and supervisory frameworks for greater transparency and accountability by policymakers. The next section reviews the development of SD indicators.

From an environmental point of view, South Africa's performance is weakened mainly by increasing CO_2 emissions and strained water and fish stock resources. Soil erosion and practices connected with commercial farming, such as the use of pesticides; add to environmental pressures (WEF, 2013:70).

2.3 SUSTAINABLE DEVELOPMENT INDICATORS

This sub-section explores SD indicators, which can be viewed as measurable and aggregated portion of information that serve to support policymakers for better informed decisions making, learning and policy adaptation.

One of the outcomes of the depression of the 1930s was the gradual development of the SNA for examining a nation's economy (Commission of the European Communities, 2001; IMF; OECD; UN; Bank, World (1994).

The SNA is a well-established methodology for producing a coherent, consistent and integrated set of macro-economic accounts that cover all aspects of economic activities (Pierantoni, 2004:98). The SNA distinguishes between measures of 'weak' and 'strong' sustainability (CEC et al., 1994). On one end of the continuum, proponents of weak sustainability support the view of replacing any natural resources used with alternative resources of an equal value (Pierantoni, 2004:93). On the other end of the continuum, proponents of strong sustainability, support that renewable resources should not be used in excess of natural regeneration (Pierantoni, 2004:93).

This research attempts to contribute the alignment of the aggregate economic measures and become a visible part of the SNA. In line with the research, Table 2.3-1 provides some essential characteristics of SD indicators.

Table 2.3-1: Characteristics of sustainable development indicators

REQUIREMENTS FOR WORKING INDICATORS	
Significance	The indicators have to be significant in the given context. A great variety of data may therefore be significant.
Representation	It has to be clear what subject or phenomenon the indicator or the data represent. An appropriate geographic scale has to be set, or an appropriate time scale for measurements or sampling the analyses of which form the basis for the indicators.
Uniqueness	The data obtained have to be unique, must not be redundant, repetitive, or duplicating any other existing information. Each indicator has to be distinctly specific and original and must not replicate what is known from other sources.
Measurement, Obtaining	It has to be technically feasible to obtain the groundwork data. The technical aspects of measurement and sampling are one of the key issues to pay attention to when designing monitoring systems and planning measurement schedules.
Cost-effectiveness	The data obtained have to be unique, must not be redundant, repetitive, or duplicating. Obtaining, processing and providing any data always costs something. Information is never free of charge. Data collection, monitoring system operation, and information sources maintenance tends to be quite expensive. The requirement for cost-effectiveness is one of the fundamental, but often ignored ones.
Environmental impact	The observed subject may be damaged or even destroyed by sampling. Measures the minimum negative environmental impact
Correction	No data are absolutely correct and some error must always be considered, even though often it is minor. Indicators have to be correct, meaning that indicators must not be charged with excessive error.
Dependence	The data have to be verified in terms of reliability, confirmed by several independent measurements, and the results may have to be obtained using significantly different methods. Data control and quality assurance is an entire important line of work.
Comparable	Most measurement, sampling, statistical surveys etc. have internationally standardised procedures. Correct and dependable data, however, are a precondition of comparability.
Transparency	Data collection and indicator definition processes have to be transparent. There has to be clarity in methods used, how the calculations were done, and so on.
Comprehension	All data and indicators assume a user, someone who takes interest in them. For any use, all data have to be comprehensible, unambiguous, and easy to present.
Communication	No data, and thus no indicators, make sense as stand-alone; indicators only become meaningful in a context. The possibility to communicate the meaning of any data or indicators is an important criterion in the evaluation.
Timing	Data and indicators seldom have a timeless meaning, therefore crucial to have and use indicator on a given point of time, which mostly means as quickly as possible.
Utilisation	The purpose of any information – fully including data and indicators – is not separate in existence, but in utilisation. Information is a type of goods that only has a price as long as there is any interest in the information.

Source: Hřebík, Třebický and Gremlica (2006:44)

Indicators can be used to measure the impact of policy decisions and can be instrumental in a policy cycle when used to measure effectiveness (Pintér, Swanson & Barr, 2004:10) as illustrated in Figure 2.3-1. In this research context, the policy cycle (Figure 2.3-1) in conjunction with the identified indicators, can be used in achieving SD strategic targets.

From 1995, the International Institute for Sustainable Development (IISD) in Swanson, and Pintér, (2006) collected extensive indicators and initiatives, focusing on the three pillars of SD. The broad list of indicators can be useful for countries' selection across different sectors, but too broad for single country application (Chaturvedi & Srinivas, 2012:1640-1641) due to the unique and complex historical, political and natural factors (Economic Commission for Africa, ECA, 2010:35). Nevertheless, from the research perspective, the development of one's 'own' set of indicators considering the unique social, economic and environmental characteristics of South Africa is crucial.

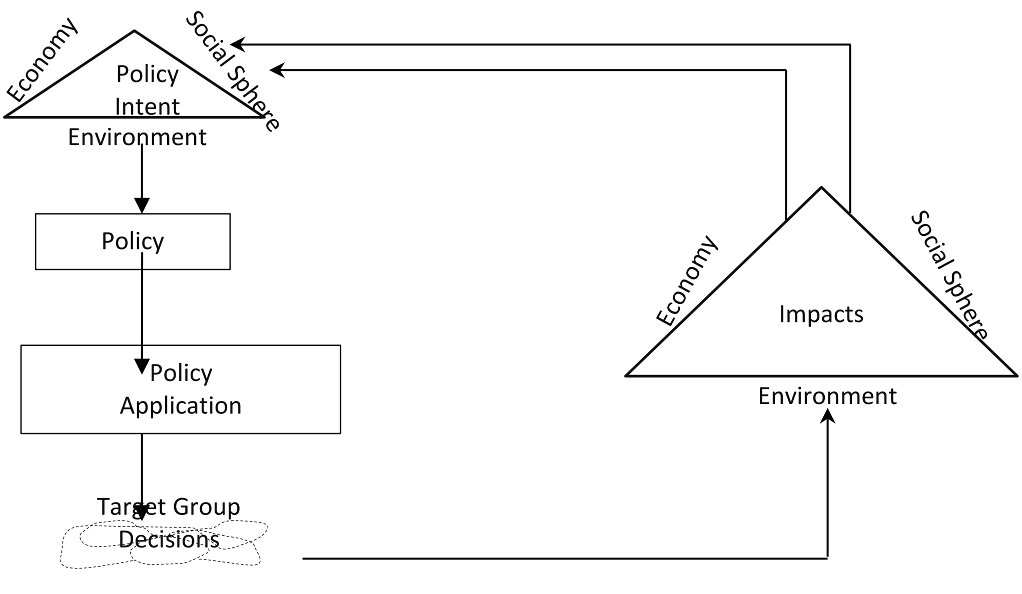


Figure 2.3-1: Policy cycle for performance assessment
Source: Pintér, Swanson and Barr (2004:10)

Gordon and Craig (2001) propose the Five Capitals Model and maintain that any government or organisation has five capitals or stocks to manage: natural, social, human, financial and physical illustrated in Table 2.3-2.

Table 2.3-2: Categories of capital assets

CATEGORIES OF SUSTAINABLE DEVELOPMENT CAPITAL ASSETS
Natural capital: the natural resource stocks from which resource flows useful for livelihoods are derived (for example land, water, wildlife, biodiversity, environmental resources).
Social capital: the social resources (for example, networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods.
Human capital: the skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies.
Physical capital: the basic infrastructure (for example transport, shelter, water, energy and communications) and the production equipment and means which enable people to pursue livelihoods.
Financial capital: the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) and which provide them with different livelihood options.

Source: Gordon and Craig (2001:14)

Sustainable development categories include (i) physical capital: economic assets such as buildings, machines and infrastructure that are the economist's usual concern; (ii) social capital: people's skills and abilities as well as the institutions, relationships, and norms that shape the quality and quantity of a society's social interactions; and (iii) natural capital: natural resources, both commercial and non-commercial, and ecological services which provide the requirements for life, including food, water, energy, fibres, waste assimilation, climate stabilisation, and other life-support services; (iv) human capital, namely: knowledge, know-how, health, security (v) environmental capital, namely: natural renewable and non-renewable resources, ecological functions (Costa et al., 2010:7-8; Pierantoni, 2004:64-65). The aforementioned categories should be considered in formulation, monitoring and evaluation (M&E) of South Africa's SD indicators. The Australian Bureau of Statistics (2003:15), in a wide ranging consultation process, selected 15 indicators shown in Table 2.3-3 as for SD headline set.

Table 2.3-3: Some indicators for SD headline set

HEADLINE DIMENSIONS	HEADLINE INDICATORS	SUPPLEMENTARY INDICATORS
Health	Life expectancy at birth	Proportions of people surviving to ages 50 and 70; Infant mortality rate; Burden of disease
Education and training	People aged 25–64 years with higher education qualification	Education participation rate for those aged 15–19; Year 7/8 to Year 12 apparent retention rate.
Work	Unemployment rate	Long-term unemployment rate; Retrenchment rate; Casual employees; People in part-time jobs
Biodiversity	Extinct, endangered and vulnerable birds/mammals	None
Land clearance	Annual area of land cleared	None
Land degradation	Salinity, assets at risk in areas affected	None
Inland waters	Water management areas, proportion where use exceeded 70% yield	Water diversions: Murray–Darling Basin; River condition (biota) index; net water use; river environment index
Air quality	Fine particle concentrations, standards exceeded	Highest one hour averages of sulphur dioxide, selected regional centres; Ozone depletion
Greenhouse gases	Net greenhouse gas emissions	Total greenhouse gas emissions (including land clearance); CO_2-e emissions
National wealth	Real national net worth per capita.	Real national assets and liabilities per capita; demonstrated and real net foreign debt
National income	Real net national disposable income per capita.	Real Gross Domestic Product per capita; proportion of the population in work; Terms of trade
Economic disadvantage-inequality	Real equalised disposable income in the second/third deciles income distribution.	Real equalised average weekly disposable income of groups of higher income households; children without employed parent. Gini coefficient
Housing	No headline indicator.	Households with housing affordability problems
Crime	Unlawful entry, assault	Homicide rate; Imprisonment rates
Social attachment	No headline indicator.	Participation in organised sports; voluntary work; marriage and divorce rates; persons living alone; homelessness; suicide; drug-related death rates

Source: Australian Bureau of Statistics (2003:15)

Established environmental indicator metrics were utilised as a source of secondary data when analysing this research. The first metrics is the *Environmental Performance Index* and its predecessor, the Environmental Sustainability Index developed by some universities researchers at Yale and Columbia. The metrics provide indication of national performance on a variety of environmental indicators (Yale University, 2012) and comprise environmental health (air, pollution, water, environmental burden of disease) and ecosystem vitality (forests, fisheries, agriculture, and climate change).

A second metric is the *ecological footprint* developed by the Global Footprint Network (2013). The Footprint includes the areas for producing the resource it consumes (bio capacity), the space for accommodating buildings and roads, and the ecosystems for absorbing waste emissions such as CO_2 (Global Footprint Network, 2013:1-2).

A third metric considered in this research is the *global adaptation index* created by the Global Adaptation Institute (GAIN, 2013), which is a pioneer in measuring the ecological resource use and resource capacity of countries. GAIN summarises a country's vulnerability in terms of food, ecosystems, habitat, health, infrastructure, and water to climate change and other global challenges in combination with the country's readiness to improve resilience. According to the latest GAIN, (2013) Index Country Rankings, Denmark, Switzerland, Australia, Norway, United Kingdom (UK) ranked as the top 5 five countries, while Sudan, Burundi, Iraq, Democratic Republic of the Congo and Democratic People's Republic of Korea were the bottom 5 Countries as illustrated in Table 2.3-4. South Africa ranked 70 up by one point from 71 in both 2009 and 2010 (International Labour Organisation ILO, 2013).

Table 2.3-4: GAIN Index Country Rankings 2013

RANK	TOP 5 COUNTRIES	SCORE	RANK	BOTTOM 5 COUNTRIES	SCORE
1	Denmark	82.6	172	Sudan	39.5
2	Switzerland	82.2	173	Burundi	39.0
3	Australia	80.9	174	Iraq	39.0
4	Norway	80.7	175	Dem. Rep. of the Congo	37.9
5	United Kingdom	79.8	176	Dem. People's Rep. of Korea	33.6

Source: Collated from International Labour Organisation (2013:1-2)

The *World Bank's Worldwide Governance Indicators Framework* (WGI, 2013) is one of the social sustainability indicators metrics considered in this research. The WGI (2013) reports aggregate individual governance indicators for 215 economies over the period 1996–2012 for six dimensions of governance, namely: voice and accountability; political; stability and absence of violence; government effectiveness; regulatory quality; rule of law; and control of corruption. The *ILO's Decent Work initiative* is another social sustainability indicator metric, which aims at measuring various elements relevant for labour conditions. Decent work is central to efforts to reduce poverty and a means for achieving equitable, inclusive and SD (ILO, 2013). Table 2.3-5 lists social and environmental sustainability indicators.

Table 2.3-5: Summary of indicators for social and environmental sustainability

SUMMARY OF INDICATORS FOR SOCIAL SUSTAINABILITY	SUMMARY OF INDICATORS FOR ENVIRONMENTAL SUSTAINABILITY
<u>Access to basic necessities</u> 1. Access to sanitation 2. Access to improved drinking water 3. Access to healthcare <u>Vulnerability to shocks</u> 1. Vulnerable employment 2. Extent of informal economy 3. Social safety net protection <u>Social cohesion</u> 1. Income Gini index 2. Social mobility 3. Youth unemployment	<u>Environmental policy</u> 1. Environmental regulations (stringency and enforcement) 2. Number of ratified international environmental treaties 3. Terrestrial biome protection <u>Use of renewable resources</u> 1. Agricultural water intensity 2. Forest cover change 3. Fish stocks' overexploitation <u>Degradation of the environment</u> 1. Level of particulate matter concentration 2. CO_2 intensity 3. Quality of the natural environment

Source: World Economic Forum (2013:63)

Three social sustainability conceptual elements identified by the WEF (2013:64), shown in Table 2.3-5, are populations' access to basic necessities, populations' vulnerability to economic exclusion and assessment of social cohesion. Three environmental sustainability elements identified by the WEF (2013:64) are the policy category, the use of renewable resources and consideration of the degradation of the environment. Table 2.3-6 presents the development indicators set for the strategic priorities of the South African Ministry of Planning in the Presidency (2009:7-8).

The strategic priorities of the South African Ministry of Planning in the Presidency in Table 2.3-6 contains only economic and social sustainability indicators, with no reference to the environmental pillar indicators. All the three pillars are important for SD in South Africa. Therefore, the development of all three pillars of SD indicators is required. In the absence of a balanced three-pillar approach, South Africa is likely experiencing difficulties in assessing and monitoring the evolution and progress made. The aforementioned absence will result in difficulties in determining and implementing appropriate policies and measures for the development of a model and framework for achieving the desired strategic priorities. To this end, the next section is a review of frameworks for measuring (sustainable) development.

Table 2.3-6: Development indicators

	DEVELOPMENT INDICATORS		
No.	**INDICATOR THEME AND NAME**	**No.**	**INDICATOR THEME AND NAME**
	ECONOMIC GROWTH		**EDUCATION**
1.	Gross Domestic Product (GDP) growth	39.	Malaria
2.	Real Per Capita GDP growth	40.	Educator: Learner ratio in public schools
3.	Foreign Direct Investment	41.	Enrolment rates: Gross Enrolment Rate, Gender Parity Index
4.	Gross Fixed Capital Formation	42.	National Senior Certificate pass rate
5.	Budget Surplus or Deficit before borrowing	43.	Matriculated with Mathematics Passes
6.	Government Debt	44.	Adult literacy rate
7.	Interest Rates: Real and Nominal	45.	Graduating SET Students
8.	Inflation measures: CPI and CPIX		**SOCIAL COHESION**
9.	Bond Point Spreads	46.	Strength of civil society
10.	Expenditure on R&D	47.	Voter participation
11.	Foreign Trade and Payments	48.	Voters per province
12.	South Africa's competitiveness outlook	49.	Percentage of women in legislative bodies
13.	Knowledge based Economy Index	50.	Confidence in a happy future for all races
14.	Black Economic Empowerment Transactions	51.	Public opinion on race relations
15.	Black and Female Managers	52.	Country going in the right direction
	EMPLOYMENT	53.	Identity based on self-description
16.	Employment	54.	Pride in being South Africa
17.	Unemployment	55.	Number of all crimes
18.	Expanded Public Works Programme	56.	Contact crime
	POVERTY AND INEQUALITY		**SAFETY AND SECURITY**
19.	Per Capita Income	57.	Property crime
20.	Living Standards Measure	58.	Aggravated Robberies
21.	Inequality Measure	59.	Detection rate
22.	Poverty Headcount Index	60.	Charges referred to court
23.	Poverty Gap analysis: Poverty gap index	61.	Conviction rate
24.	Social Assistance Support	62.	Total numbers of inmates
25.	People with Disabilities	63.	Road accidents
	HOUSEHOLD ASSETS		**INTERNATIONAL RELATIONS**
26.	Dwellings	64.	Peace operations
27.	Potable Water	65.	Democratic elected governments in Africa
28.	Sanitation	66.	Real GDP growths in Africa
29.	Electricity	67.	Sustainable tourism
30.	Land Restitution	68.	Mission operations and diplomats trained
31.	Land Redistribution	69.	Agreements
	HEALTH		**GOOD GOVERNANCE**
32.	Life Expectancy	70.	Tax returns
33.	Infant and child mortality rate	71.	Audits
34.	Severe malnutrition under five	72.	Corruption perceptions
35.	Immunisation coverage	73.	Budget Transparency
36.	Maternal Mortality Ratio	74.	Public opinion: Delivery of basic services
37.	HIV Prevalence	75.	Ease of Doing Business
38.	Tuberculosis	76.	Green-house gas emissions

Source: South African Ministry of Planning in the Presidency (2009:46)

2.4 FRAMEWORKS FOR MEASURING (SUSTAINABLE) DEVELOPMENT

Various scholars, for example Ehrlich and Holdren (1971), Commoner (1972), Grossman and Krueger (1993; 1995); Beckerman (1992), Copeland and Taylor (2004), and Van Alstine and Neumayer (2008) have examined the various views of the dynamics of (sustainable) development, resource use and environmental impacts, by assuming one of the following major views: (i) the IPAT equation; (ii) the EKC and; (iii) the ecological metabolism and structural change.

2.4.1 The IPAT Equation

Ehrlich and Holdren (1971) and Commoner (1972) formulated the IPAT equation, which can be used to express the extent to which each component contributes to an unsustainable situation and assess an economy's pathway towards sustainability. The equation suggests that an environmental impact (I) depends on the levels of population (P), affluence (A) and technology (T):

$$\textit{Environmental impact} = \textit{Population} \times \textit{Affluence} \times \textit{Technology}$$

According to the IPAT equation, an increase in population is proportional to an increase in resources demand. Important policy implications arising from the IPAT equation include the need to develop more efficient technologies and the importance of implementing strategies for curbing population growth.

2.4.2 The Environmental Kuznets Curve (EKC)

The EKC follows a similar logic to that applied to the original inverted-U curve formulated by Kuznets (1955), which deals with income inequality and income per capita. Scholars, for example, Beckerman (1992), the International Bank for Reconstruction and Development (IBDR, 1992), Grossman and Krueger (1993; 1995), Copeland and Taylor (2004) and Van Alstine and Neumayer (2008) examined the relationship between growth and the environment using the EKC hypothesis and came up with mixed findings, such as that in the early stages of development, there is a deterioration of environmental quality as a consequence of increasing physical capital intensive activities, rather than human capital intensive. The findings also showed that as a society achieves a higher level of income, the "turning point" environmental indicators should start to display improvements. This research notes that the various mixed findings with regard to the EKC hypothesis present a challenge for policymakers because of the differing policy implications. For instance, Beckerman (1992:16-18) points out that EKC also implies that countries can grow out of environmental problems over time and questions whether the turning point is automatic or due to government policy and whether any irreversible damage is done before the turning point.

2.4.3 The Socio-Ecological Metabolism and Structural Change

Socio-ecological metabolism, a concept that originated in the biological sciences, takes into account resource use and environmental impacts and illustrates how the socio-ecological impacts change during the process of structural transformation (Fischer-Kowalski & Haberl, 2007; Krausmann, Fischer-Kowalski, Schandl & Eisenmenger, 2008). Sustainable Development involves a profound transformation of the societal metabolism (Holmberg & Samuelsson, 2006:9). The metabolic profiles of different types of economies are profoundly influenced by factors such as trade and foreign stocks (Giljum, Dittrich, Bringezu, Polzin & Lutter, 2010:6).

In this research context, the challenge is for South Africa to propose strategies for reconciling the imperatives of structural transformation for the three pillars of SD at both national and global levels. The next section reviews theories that have direct and indirect impact on the construct of SD in South Africa through research in the NSI.

2.5 SUSTAINABLE DEVELOPMENT THEORIES

This section reviews relevant theories that have direct and indirect impact on the construct of SD in South Africa, which result from research commercialisation in the NSI. Theory plays an important role and adds meaningfulness in explaining the lens through which this research is examined and provides an important foundation for the development of a conceptual framework for this research. The use of theoretical framework also serves as a guide during research analysis and interpretation of results.

Schunk (2008:23) defines a theory as "an organised set of related principles explaining observed events/relationships". Theories make predictions in the form of "if…, then…" statements that can be tested." Moore and Kearsley (1996:197) further state that "theory gives us a common framework, a common perspective, and a common vocabulary that helps us ask questions in a sensible way and make sense of problems". Pieterse (2010:9) views sustainable development theory as that which takes into consideration a country's economic, sociological, anthropological, historical, political and even ideological factors. The theory of SD presently borrows from development, sociology and economic related fields (Decleris, 2000; Pieterse, 2010:9) as indicated in Table 2.5-1.

Table 2.5-1: Global hegemony and development theories

HISTORICAL	CONTEXT	HEGEMONY EXPLANATION	DEVELOPMENT THEORIES
Nineteenth century	British Empire Colonial	Anthropology, social Darwinism	Progress, evolutionism
1890–1930s	Latecomers, colonialism	Classical political economy	Catching up
Post-war boom	US hegemony	Growth theory, structural functionalism	Modernisation
Decolonisation	Third World nationalism, G77	Neo-Marxism	Dependency
1980s >	Globalisation Finance and corporate capital	Neoliberalism, monetarism	Structural adjustment
1990s >	Rise of Asia, big emerging economies, BRIC	Capabilities, developmental state	Human development

Source: Pieterse (2010:9)

Table 2.5-1 further indicates that (sustainable) development is intrinsically a field of multi-level negotiation, which requires the adoption of a multidimensional and holistic approach in this research context. Therefore, due to the cross-disciplinary nature of the concept of development, the theories reviewed in this research have been adapted from constituent disciplines such as economics, sociology and agricultural science. Generally, (sustainable) development actions need all of the following theories in new combinations: classical political economy, modernisation, dependency, market-led (neoliberalism) and society-led (alternative development).

2.5.1 The Modernisation Theory

The modernisation theory and the associated stages of growth (evolutionary) theory are linked to Rostow (1960; 1990) who identifies five stages of economic growth that lead to development, namely: the (i) traditional society (an agrarian-dependent society with limited access to S&T); (ii) preconditions of take-off; (a transitional period to modernity, a period when developing society becomes aware of the need for advancement); (iii) take-off (the period of rapid industrial and technological growth); (iv) drive to maturity (a period of long sustained growth); and (v) age of high mass consumption (a period of economic growth when society moves towards demanding durable consumer goods and services).

The WEF (2013:9-10) adapted Porter's (1990) theory in formulating three stages of development, which bear some similarities with Rostow's (1960) five stages of economic growth theory summarised in Table 2.5.1-1.

Table 2.5.1-1: Three stages of development

DEVELOPMENT STAGES		BRIEF DESCRIPTION OF DEVELOPMENT STAGES
1.	Factor-driven	The GCI assumes that economies in the first stage are mainly factor-driven and compete based on factor endowments—primarily low-skilled labour and natural resources. Stage of development hinges primarily on well-functioning public and private institutions (pillar 1), a well-developed infrastructure (pillar 2), a stable macroeconomic environment (pillar 3), and a healthy workforce that has received at least a basic education (pillar 4).
2.	Efficiency-driven	Institutions and countries develop more efficient production processes and increase product quality, due to increased wages and cannot increase prices. Competitiveness is increasingly driven by higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labour markets (pillar 7), developed financial markets (pillar 8), the ability to harness the benefits of existing technologies (pillar 9), and a large domestic or foreign market (pillar 10).
3.	Innovation-driven	The stage entails companies competing by producing new and different goods through new technologies (pillar 12) and/or the most sophisticated production processes or business models (pillar 11) in order to sustain increasing higher wages and the associated standard of living.

Source: Collated from World Economic Forum (2013:9-10)

Table 2.5.1-1 implies that globally countries are at different stages of development, which have implications on the three pillars of SD, mainly the environmental pillar. The modernisation theory proposes that if 'less-developed' countries (LDCs) are to become 'developed', the path taken by the 'developed' countries, which is closely tied with industrialisation, should be followed. Scholars such as Inkeles and Smith (1974), Webster (1984), Harrison (1988) and Saha (1992) have assumed the existence of a direct causal link between five sets of variables, namely: modernising institutions, modern values, modern behaviour, modern society and economic development.

Figure 2.5.1-1 shows that South Africa, including other 31 economies out of the total 148 ranked economies, falls under stage 2: efficiency-driven stage of development. According to Fagerlind and Saha (1989:21-24), underlying assumptions of the modernisation theory such as modern values and behaviour by individuals eventually leads to socio-economic development are unrealistic. Therefore, because society is not the sum total of individuals who live in the society, Fagerlind and Saha (1989:21-24) have refuted the modernisation theory. Offiong (2001:40-46) also criticises the modernisation theory as one that ignores the global forces, treats third-world societies as self-contained units, whereby political, social, or economic systems can be analysed; and ignores world-historical development of transitional structures. Matunhu (2011:65-66) disapproves the modernisation theory as based on deterministic reason of a linear model of socio-economic development and externally-initiated changes. In the 1980s, Matunhu (2011:66) notes that Africa was victim of the failed ‘Eurocentric’ IMF-imposed economic structural adjustment programme (ESAP). The failure of the ESAP project to pull the continent out of poverty and underdevelopment maybe attributed to disregard of the cultural, social, political and traditional values of the recipient countries.

	Rank (out of 148)	Score (1–7)
GCI 2013–2014	**53**	**4.4**
GCI 2012–2013 (out of 144)	52	4.4
GCI 2011–2012 (out of 142)	50	4.3
Basic requirements (40.0%)	**95**	**4.2**
Institutions	41	4.5
Infrastructure	66	4.1
Macroeconomic environment	95	4.4
Health and primary education	135	3.9
Efficiency enhancers (50.0%)	**34**	**4.5**
Higher education and training	89	3.9
Goods market efficiency	28	4.8
Labor market efficiency	116	3.9
Financial market development	3	5.8
Technological readiness	62	3.9
Market size	25	4.9
Innovation and sophistication factors (10.0%)	**37**	**4.1**
Business sophistication	35	4.5
Innovation	39	3.6

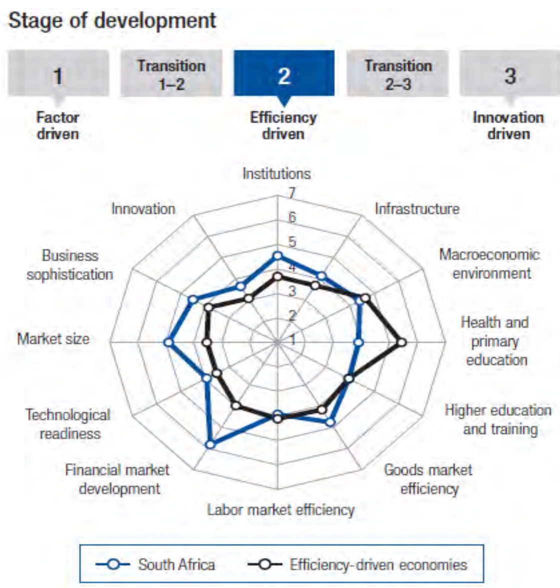


Figure 2.5.1-1: South Africa's Global Competitiveness Index 2013–2014
Source: WEF (2013:345)

2.5.2 The Dependency Theory

Critics of the evolutionary theory such as Baran (1957), Frank (1972b), Frank (1967) and Brett (1974) propose the dependence theory as an alternative theoretical framework for interpreting and explaining development and underdevelopment. The alternative scholars such as Offiong (1980:7) and Frank (1972a:14) propose that persistent poverty of the third world (the Global South) is an image of dependency on ‘the Global North’. Dependency, according to Dos Santos (1973:76), is a conditioning situation of causal relationship, which Rodney (I973:21-22) views as a product of capitalist, imperialist and colonialist exploitation. The chief feature of the dependency school places the development process firmly within a globally defined historical context (Smith, 1979:248), a ‘centre’ of wealthy states and a ‘periphery’ of poor, underdeveloped states determined by the manner of integration (Ikejiaku, 2008:2). “Dependency means… that the development alternatives open to the dependent nations are defined, constrained or limited by its integration into and function within the world market system” (Offiong 1980:76). Kenya, for example, continues to express its displeasure at the IMF and the World Bank for forcing policy changes on it (Ikejiaku, 2008:3), the conditionality of the so-called free market rules to the economies structural adjustment programme ‘SAP’ (Biersteker, 1993: Ikejiaku, 2008:3).

According to Frank (1972b:4), underdevelopment is one of the results of dependency, whereby resources are being actively used, with the benefits going to the dominant states and not for the poorer (resource owners) countries. Frank (1967:25) further states that "underdevelopment is not an original state, but a result of economic capture and control of backward regions by advanced metropolitan capitalism". Dos Santos (1971:226) states that:

> [Dependency is]...an historical condition which shapes a certain structure of the world economy such that it favours some countries to the detriment of others and limits the development possibilities of the subordinate economics...a situation in which the economy of a certain group of countries is conditioned by the development and expansion of another economy, to which their own is subjected.

In defining the concept, Dos Santos (1971:226) emphasises the historical dimension of the dependency relationships, with the assumption that economic and political power are heavily concentrated and centralised in the industrialised countries. Scholars who refute the dependency theory such as Webster (1984), Fagerlind and Saha (1989), Harrison (1988) and Nnaemeka (2009) present a different political alternative for development. The first alternative is the self-reliance model, which proposes that although development can be facilitated by the help of others, citizens should take responsibility for their country's development (Nnaemeka, 2009:44). Development cannot be received and should be experienced as a participation process (Nnaemeka, 2009:44). Nevertheless, a policy of self-reliance according Davids, Theron and Maphunye (2009:9-17), should be interpreted as endorsing a policy of controlled interactions with the world economy for the welfare of the larger citizenry. A second alternative is the people-driven development model, whereby the urgent primary principle is the citizens being agents, the means and the end of development of bottom-up nation-building strategy.

Social scientists such as Webster (1984), Fagerlind and Saha (1989) and Harrison (1988) argue that the dependency theory's implication that third world economies are static is erroneous and has also failed to account of the fact that some dependent nations have become wealthy. Many Asian economies, and newly industrialising countries (NICs), such as South Korea, Taiwan and Hong-Kong, have developed along capitalistic, open lines, serving as an empirical contradiction to dependency theory (Kay & Gwynne, 2000:52). Bad government, according to Fagerlind and Saha (1989:22) is the single most important cause of failure in LDC. Furthermore, Kay and Gwynne (2000:52) assert that the "associated-dependent development" by Cardoso and Faletto (1979) is more relevant, than the construct of "development of underdevelopment" version of Frank's (1967; 1972a) dependency, which is at odds with the development achieved by the Asian economies. Underdevelopment, in part, may be due to past policy choices by LDC imitating industrialisation (Srininvas & Sutz, 2008:10). Consequently, this research posits that policy-makers should design specific policies within the LDC capabilities. However, Ikejiaku (2008:7) puts forward the view that domestically-inspired policy choices in LDCs and some LDC are sometimes limited by massive debt obligations. Multilateral institutions such as the World Bank, the IP Organisation, the World Trade Organisation (WTO) and the IMF continue to exert a strong influence over LDCs and developing economies domestic policies (Onimode, 1989:12; Ikejiaku, 2008:3). Development, according to Hirschman (1958:41), depends not so much on finding optimal combinations of productive factors and resources as on using—for development tasks—resources and capabilities that are badly utilised, hidden, or scattered. Consequently, the research views underdevelopment essentially as a state where important potential has not yet been exploited sufficiently within the NSI.

The key to getting SD right appears as if it is for the government to do well in the narrow range of tasks that Adam Smith, cited by Mankiw (2006:6) and Wade (2010:150), prescribed: ‘‘little else is required to carry a state to the highest degree of opulence from the lowest and not much more barbarism but peace, easy taxes and a tolerable administration of justice’’. Indeed “a consensus seems to have emerged that corruption and other aspects of poor governance and weak institutions have substantial, adverse effects on economic growth” (Mauro, 2004; Wade, 2010:154). The World Bank and IMF have built governance reforms into lending conditionality. Seligson (2002;410) states that “so widespread is confidence in these findings [conditionality] that international lending agencies have embarked upon major efforts to reduce corruption, conditioning many of their loans on formal, widespread efforts to clean it up”. This research supports the need for long-term development finance and technical assistance for SST in Africa without conditions attached to achievement of externally required sustainability targets.

2.5.3 The Human Capital Theory

Critics of the evolutionary and dependency theories such as Blaug (1985) and Schultz (1961:1981) support the human capital theory (HCT) as being the most productive course to national development of any society. The HCT rests on the nation’s human capital for the advancement of the population (Schultz, 1961). Education contributes directly to the growth of the national income of societies and is not merely a form of consumption (Schultz, 1961:640-641). The HCT assume that improved technology leads to greater production and that employees acquire skills for the use of technology through formal education. Blaug (1985:18-15) criticises the HCT and contends that boosting the level of education in a society may increase inequalities in the distribution of income. Fagerlind and Saha (1989) also view the HCT as appealing but fraught with methodological problems such as difficulty in measuring how education contributes to labour quality.

2.5.4 The African Renaissance Theory

Other developmental theorists such as Korten (1990) and Matunhu (2011) argue that the African renaissance theory encourages Africa to act in a world, dominated by the metropolitan countries, suggesting that micro-level development and poverty reduction should be the primary focus. The African renaissance theory, unlike its predecessors, advocates for local solutions, pluralism, community-based solutions and reliance on local resources. The future depends on achieving the transformation of institutions, technology, values and behaviour consistent with ecological and social realities in Africa (Korten, 1990:4; Matunhu, 2011:71).

2.5.5 The Systems Theory

Systems theorists, for example Easton (1965), Freeman (1987:2004), Decleris (2000) and Johnson, Edquist and Lundvall (2003) denounce one-sided economic growth and propounded an integrated developmental approach. Easton (1965) is renowned for his application of systems theory to political science. Easton (1965) proposed that a political system could be seen as a delimited (that is all political systems have precise boundaries) and fluid (changing) system of steps in decision making. System approaches take a broader view of policy as an institutionalised multi-actor and a multi-dimensional process (Lafferty et al., 2005:255). The Stockholm International Conference on the environment (1972) can be regarded as the starting point of the new, systemic approach in SD and is composed of the sum of its principles and corresponding action plans (Stockholm Declaration, 1972; WCED, 1987; Decleris, 2000). The system theory focuses on the contribution to policy making of interrelated forces (Hanekom, 1987:46; OECD, 2005a). This research views the systems theorist approach as being relevant to the construct of SD within the NSI. To this end, this research provides the Chapter summary.

2.6 SUMMARY

This Chapter has served as a theoretical foundation that addressed the construct of SD frameworks and theories and a broader SD agenda mainly from the South African perspective. The elements considered for the construction of SD, namely: the social equity pillar, the sustainable structural transformation, MDGs, the economic pillar and the environmental pillar has been examined. The evolution of SD and SD indicators has been undertaken. Frameworks for measuring (sustainable) development were explored namely: the IPAT equation, the EKC and ecological metabolism and structural change. Relevant theories that have direct and indirect impact on the construct of SD were examined, namely: the modernisation theory, dependency theory, the human capital theory among others. The chapter has shown that addressing the relationship among research commercialisation, STI and SD provides insights on how the constructs influence each other. To this end, the next chapter is a review of public administration and public policy in South Africa.

CHAPTER THREE

PUBLIC ADMINISTRATION AND PUBLIC POLICY IN SOUTH AFRICA WITH REFERENCE TO SUSTAINABLE DEVELOPMENT WITHIN THE NSI

3. PUBLIC ADMINISTRATION

Chapter Two examined the construct of SD within the NSI. This chapter undertakes a literature review with regard to public administration and public policy in South Africa. This chapter examines policies with regard to sustainable (development), research, innovation and NSI in an integrated manner because, as mentioned earlier, the traditional separation of the four policy areas is undesirable. This is because integrated policies approach should be informed and guided by the South African historical, political socio-economic and environmental context.

3.1 INTRODUCTION

In this research context, the NSI policy framework has been used to provide a foundation for reviewing South Africa's collective efforts among the NSI actors in an integrated and holistic manner. Furthermore, the complex nature of the policy interaction is relevant in addressing SD in South Africa, for research commercialisation in the NSI. Therefore, this Chapter examines the policy factors that appear to shape the structure and function of the current NSI. In the research context, other secondary policies and factors that influence the responsive inclination and the adaptive capacity of the NSI are related to the four fundamental policies. Structures supporting norms are essential for identifying, creating and utilising the local level of implementation of policies (for example education policies and practices in HEIs) (Wickenberg, 2006:111). In dealing with the 'wicked challenges' facing South Africa, innovative economies prosper in situations where the public sector is innovative. The financial crisis of 2008 and 2009, in which globalised banking systems collapsed and governments were forced to intervene on a massive scale has illustrated the added value of ensuring financial, economic and social stability.

This chapter is organised as follows: section 3.2 reviews literature on public administration within the construct of SD in South Africa through research in the NSI. Section 3.3 examines public policy in South Africa within the research topic. Section 3.4 entails a discussion of South Africa's NSI policy development, making reference to existing policy framework such as the 1996 White Paper for S&T in South Africa. Section 3.5 is a summary of OECD South African NSI country review. Section 3.6 undertakes a review of South African NSI innovation policy, while Section 3.7 explores innovation policy interventions and evolution of various innovation policy models relevant for the construct of SD in South Africa through research in the NSI. Section 3.8 is a review of sustainable development policies mainly from a South African perspective, in terms of the historical perspective of South African sustainable development policies, the national strategy for SD and the NDP. Section 3.9 is a literature review on policy indicator mainly from a South African perspective, while section 3.10 undertakes literature review on research and knowledge policies within the NSI. Section 3.11 reviews policy challenges facing South Africa in the context of sustainable development based on research commercialisation in the NSI. Section 3.12 is a summary of the chapter. Having provided the introduction, the next section considers literature on public administration within the South African NSI.

3.2 PUBLIC ADMINISTRATION

This section reviews literature on public administration within the construct of SD in South Africa through research in the NSI. This research argues that public administration is a strategic factor and one of the key preconditions for SD in South Africa. This research acknowledges that there is a dearth of sources from South African and international authors on the discipline of Public Administration. The inadequacy of administration in South Africa has now been recognised as a major obstacle to development, perhaps more serious an obstacle than the lack of capital or foreign aid (Davids et al., 2009:65; De Coning, 2006:267; Cloete, 2004:84). This research shares a similar view with United Nations (2005:10) that the future of public administration lies in the setting up of measures for reaffirming the developmental role in an open, participative, knowledge-sharing, innovating and results-oriented service-delivery system.

Public administration emphasises the “what” and the “how” of public service (Cloete, 2004:83). Public administration institutions (legislative, political executive, administrative executive, and judicial) exist to provide public goods and services for the maintenance of the state (Cloete, 2004:84). De Coning (2006:26) defines public administration as a set of the various processes and specific functional activities of the government institutions that operate within a particular environment in order to improve the general welfare of society by providing services, products and activities. Nigro and Nigro (1989) cited in Stillman II (2010:2) views public administration as a cooperative group effort in public setting that covers the executive, legislative, and judicial branches and that has an important role in the formulation of public policy. Nevertheless, Mosher (1956:177) states that:

> “Perhaps it is best that public administration is not defined. It is more an area of interest than a discipline, more a focus than a separate science… it is necessarily cross-disciplinary. The overlapping and vague boundaries should be viewed as a resource…”

This research views public administration as an opportunity to enhance innovation and learning capabilities in South African NSI. Having reviewed the construct public administration, the next section examines public policy in South Africa within the research topic.

3.3 PUBLIC POLICY

In South Africa not only has innovation moved to centre-stage in the last decade in policy making, but there is a realisation that a co-ordinated, coherent, whole-of-government approach is required. The public sector constitutes a network of actors similar to the NSI sphere. At the root of the complex NSI interactions is deeply embedded policy-making of increasing coordination, dialogue and cooperation managed by a highly capable public administration (Evans & Rauch, 1999; Wade, 2004a:7). The specific nature of the public sector is that of "the binding allocation of public values for society as a whole" (Easton, 1965:25). Public policy entails "a comprehensive framework of and/or interaction", which includes R&D funding policy, taxes, IP, regulations, standards, and market access policies (Botes, Brynard, Fourie & Roux, 1992:195-196; OECD 2007b:11). A goal intention or policy adopted by a government (whether related to the economy, environment, or society) is formulated in a policy statement (Costa et al., 2010:12). Acts are the written embodiment of policies, which the government institutions work within to achieve specific policy objectives (Du Toit & Van der Waldt, 2009). This research endorses the definition of policy by the following actors:

- Rainey (2006:7) defines policy as "a declaration and implementation of intent".
- De Coning, Cloete and Wissink (2011:6) define policy as "the authoritative allocation through the political process, of values to groups or individuals in the society", as "a kind of guide that delimits action".
- Starling (1979:4); in De Coning (2006:14).

Du Toit and Van der Waldt (2009:17) further state that a policy is a declaration of intent. A policy is the direction to be followed to attain specific aims (Botes et al., 1992:19; Hertin & Berkhout, 2002:26-27). A policy can be seen as a hypothesis containing initial conditions and predicted consequences. If X is done at time t_1, then Y will result at time t_2 (Pressman & Widavsky, 1973: xiii) cited in Hupe and Hill, (2006:18). Further, Hupe and Hill (2006:19) note that policy determines action, while policy intentions predict policy performance in a 1:1 relationship (Hupe & Hill, 2006:18). According to March and Olsen (1987:14), policy making implies "matching institutions, behaviours, and contexts in ways that take time and have multiple, path-dependent equilibrium, thus...susceptible to timely interventions to affect the meander of history and deliberate efforts to improve institutional adaptability".

Public policy begins with theories, models, mental maps and metaphors (Parsons, 1995:58). In this research context the activity of theorising about public policy is like drawing a map for addressing SD in South Africa as a consequence of research commercialisation in the NSI. Hanekom (1987:45) observes that:

> In public policy making, theories are utilised to explain the policy-making process. Furthermore, simplification of policy making is enhanced by using models to present problems in acceptable dimensions, while it appears that the various perspectives on policy making could also contribute towards greater clarity of the process. Although no universally accepted or agreed-upon theory of the policy-making process exists, it appears that a useful model should include at least the phases of goal identification, authorisation, and public statement of intent, implementation and evaluation.

The nature and application of the theories and models in the field of policy making is highly dependent on the problems at hand. Policies are jellylike in nature (Moharir, 1986:15; De Coning et al., 2011:33) and must be thought of as seashells… with no apparent beginning or end… (They) are kinetic; they are fragile (Starling, 1979:11). Hanekom (1987:8) remarks that all (public) policies are future-oriented.

Policy models can be classified according to various categories, which have been identified for examining the construct of SD through research in the NSI. The first category comprises the analysis of the development policy content models (that is what to do) (De Coning et al., 2011:36). The rational-comprehensive decision making model can be used in exploring what to do with policy consequences (Hogwood & Gunn, 1984:44-47; Hanekom 1987:8; Anderson, 2006). The second category involves the analysis of policy making process models (who is involved, why, when and how). The elite/mass model is a process model, which assumes the small elite group (usually the government) is solely responsible for policy decisions (Anderson, 1979:19-20); The third category consists of the analysis of functional policy stages phase's models (how policy comes about, how policy outcomes are achieved). Policy stages models includes the sequences model by Hogwood and Gunn (1984), the Bardach's (2009) eight-fold path for effective problem solving and the generic process model by De Coning (2006), which is specific for key considerations in South African policy-making endeavours. The fourth and final category involves explaining policy from a general macro-level systems perspective models, which includes the Wissink system (input-output) model (Wissink, 1990:31) and Dror (1968:163-196) and the chaos, quantum and complexity distinctions model by Cloete (2006). Chaos may be better described as the study of complex, dynamic, deterministic, non-linear systems that reveal patterns of order out of seemingly chaotic behaviour (Cloete, 2006:55).

The SA DST Ministerial Review Committee (2012:88-89) envisioned a tripartite model as being useful for describing how the South African policy making structure can influence the NSI responsiveness. In this research context, the responsiveness of the NSI in meeting its intrinsic mandate is most critically dependent on effective and voluntary joint policymaking, planning and coordination at the central NSI policy-making platform. Within the tripartite model, the first level is the central policy-making platform, where priorities in innovation-driven development are recognised and the commitment to collaborate by sectoral leadership is secured. The second level is the policy coordinating platform, which provides several key functions such as the coordination and execution of priority projects identified by the central policy structure. The third level is the NSI performing agents, where 'coal-face' collaboration and project performance is undertaken. This level can be constituted by the South African research performing institutions (SA DST Ministerial Review Committee, 2012:88-89). Figure 3.3-1 indicates that the policy cycle entails policy stages and feedback loops, namely: agenda setting, policy formulation, policy coordination, implementation and policy (Cloete, 2004:138; Lafferty et al., 2005:34; OECD, 2005b:22; Alberti & Bertucci, 2006:12-14).

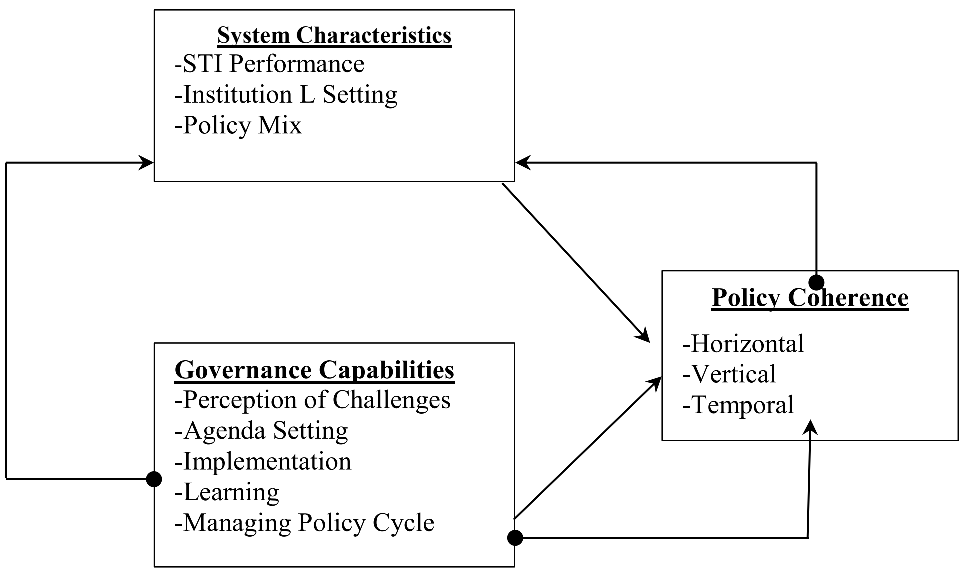


Figure 3.3-1: Policy setting cycle for coherence of innovation policies
Source: Lafferty, Ruud and Larsen (2005:34)

Figure 3.3-1 further indicates that policies are both horizontal and vertical. Scholars such as Lall and Teubal (1998), Lundvall and Borrás (1998), Rodrik (2007) and Freitas and von Tunzelmann (2008:1448-1456) recognise that an effective innovation policy requires coordination of multiple layers of support. In South Africa, there is a need for improvement in interaction and coordination among the four existing policies, namely: (sustainable) development, research, and innovation and

NSI policies. The SA DST has a number of special responsibilities for the NSI coordination. However, only very limited horizontal and vertical coherence and integration of purpose and effort between the various South African NSI agencies has been achieved (OECD, 2005c:45-47; OECD, 2007a:109-111). The NACI can be viewed as encouraging coherence, however the agency function is compromised by the fact that NACI reports to DST. Responsiveness of the South African NSI will require an overlap and coordination between the various layers of the NSI in order to overcome vertical insulations.

Lundvall and Borrás (1998:12-23) identified three features of a broadly-oriented innovation policy as firstly consisting of policies affecting the ability to innovate and absorb change, such as human and resource capacity and capability development. Secondly, as consisting of policies affecting the pressure for change, such as trade and competition policy, and, thirdly consisting of policies designed for change such as socio-economic and regional policies with redistribution objectives.

There are various models, which can be applied to measure policy success in various policy cycle stages. This research has selected the ten-factor (interdependent) model by Pinto and Slevin (1988:483-512), originally developed by Bavelas (1968) to provide criteria for evaluating policy success during various stages of the policy cycle as shown in Table 3.3-1.

Table 3.3-1: Application of the ten (interdependent) success factor onto the policy cycle

TEN (INTERDEPENDENT) SUCCESS FACTOR
STRATEGIC FACTORS- UPFRONT "PLANNING" 1. ***The policy mission*** entails clearly defining objectives at the policy outset and an implementation strategy. Defining the policy is critical pre-requisite to the chances of subsequently delivering and implementing the policy successfully (Morris & Hough 1987).
2. ***Top management support*** provide with authority, subtle control, direction, support, environment, and is instrumental in securing policy resources (such as financial, manpower, time) and have an impact on the ultimate policy acceptance or (Schultz & Slevin 1975; Beck, 1983; Nutt, 1983). The institutional executives should be strong key drivers for the policy process.
3. ***Policy schedule/plan*** refers to the degree to which specifications in terms of time schedules, milestones, manpower, and equipment required are made. Ginzberg (1979) compares planning and scheduling with the Lewin (1958) 'Unfreezing-Moving-Freezing' model, whereby the planning and scheduling is the moving stage. Kolb and Frohman (1970) view planning as necessary to the forward-going change step into the new system. Baker, Murphy and Fisher (1988:903) state that there no such claim as "*the operation was a success but the patient died*". Rather than waiting for a post policy crisis (for example environmental lobbies) to organise for 'fire-fighting' meeting, key/critical processes should be reviewed on monthly or semi-annually basis and for example, sustainability plans/schedule updated accordingly.

TEN (INTERDEPENDENT) SUCCESS FACTOR
TACTICAL FACTORS- "ACTION" OR OPERATIONAL ORIENTED. 4. ***Client consultation***, which Kolb and Frohman (1970) viewed as the first stage in a change process and implementation. Manley (1975) found policy (which can be applied to policy as a major policy) support is proportional to client consultation. Poor policy consultation can negatively affect the implementation stages.
5. ***Personnel issues*** require taking into consideration issues as recruitment, selection, and training required by the policy team. Hammond (1979) developed a contingency model that include "people" as a situational variable, whose skills, knowledge, objectives and personalities ought to be taken into consideration. The policy steering committee should comprise diverse knowledgeable members.
6. ***Technical tasks*** the importance of availability of adequate technical expertise and technology to support the policy process. Alter (1979) attributed two of the risk factors to technical incompatibility with the system. Tools known as "systems management concepts" including work breakdown structures, life cycle planning, configuration management, and status reports can be incorporated in policy process cycle. According Baker et al. (1988:906), appointment of a competent consultant to handle and facilitate the policy life cycle such as integration or risk can have a positive impact in the policy processes and interfaces.
7. ***Client acceptance*** refers to the "selling" the final policy to ultimate stakeholders and NSI network actors, in the process, determining the efficacy of the policy. Assuming policy acceptance is major policy management mistake. Stakeholders' participation in early policy stages Lucas (1979) and using "intermediaries" can improve policy acceptance (Manley, 1975; Bean & Radnor, 1979; Shenhar & Dvir, 2004).
8. ***Monitoring and feedback*** proactive monitoring and control, of policy elements such as schedule, quality and performance ensure no deficiencies are overlooked. Formal use of monitoring and control tools and techniques can be utilised.
9. ***Communication*** exchange of information policy stakeholder groups. Participative decision making and problem solving within the policy team is highly correlated with success (Baker, Murphy & Fisher 1988:909). However, public participation in the decision making often delays and hampers policy and reduces the probability of success (Baker, et al., 1988:909). Public participation can sometimes be minimised and circumvented as much as possible, when desirable.
10. ***Troubleshooting*** ability to respond to arising problems and possibly forestalling potential problems. Proactive troubleshooting is vital during the entire policy cycle.

Source: collated from Pinto and Slevin (1988:483-512); Baker, Murphy and Fisher (1988:902-919)

Table 3.3-1, indicates that the success factors are concerned with consulting with, and selling to, the concerned NSI actors, which should be an integral and perhaps even dominant criteria. This research argues that policy cycles commence with an effective policy plan. Figure 3.3-2 proposes a model that can be utilised to conceptualise planning for a policy life phases. The action theory posits that planning should inform, not dictate management decisions (Bolivar 2007). Planning refers to "an objective consideration of the future" (Cleland & Ireland 2007:121), which means 'planned in' and not 'inspected in'.

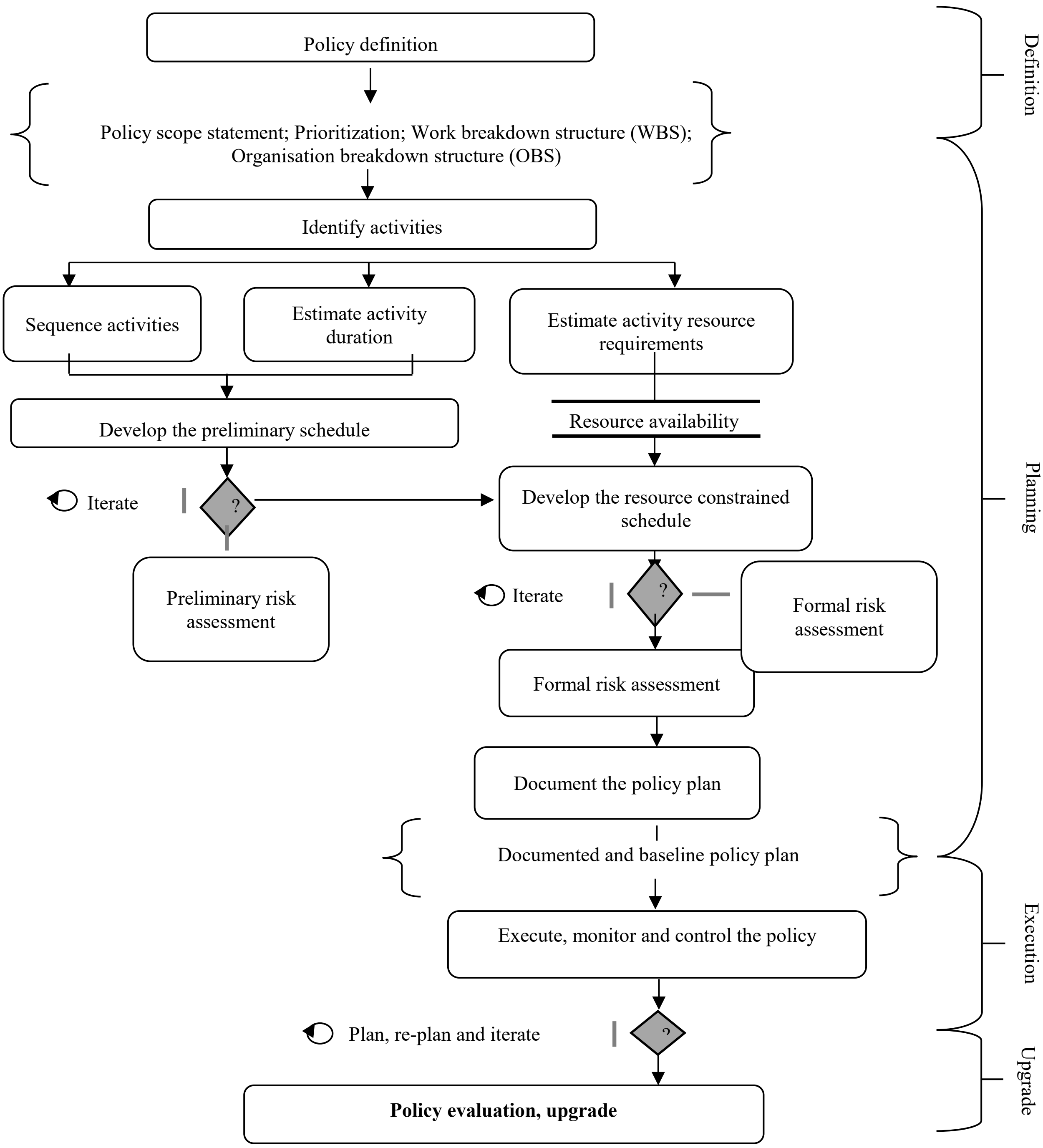


Figure 3.3-2: Policy planning model
Source: Fraser (2011:113)

Elements of an integrated policy (Figure 3.3-2) relevant to South African policy making are (i) the policy plan outlining the activities, tasks, dependencies and timeframes: (ii) the resource plan listing the labour, equipment and resources required; (iii) the financial plan identifying the cost of equipment, projects and resources; (iv) the quality plan providing quality targets, assurance and control measures; (v) the risk plan highlighting potential risks and actions to be taken to mitigate risks; (vi) the acceptance plan listing the criteria to be met to gain stakeholders policy acceptance; (vii) the communication plan describing the effective basis for coordination; vii) the procurement plan identifying for example innovations, knowledge, products and services to be sourced internally and externally and; (viii) other plans tailored to the individual policies (Fraser, 2011:113).

The fifth and the last of TYIP SA DST (2008:6) key principles states “Life-cycle planning: R&D infrastructure must be considered over the long term, including depreciation, skills needs and running costs”. The SA DST Ministerial Review Committee (2012:159) recommends undertaking a life-cycle planning for each of the various South African NSI infrastructure items. Figure 3.3-3, adapted from Goetsch-Davis (2010:603), provides 20-steps, which fit into a typical planning life-cycle process.

Step one, in the context of this research context, consists of top management commitment using both bottom-up as well as top-down approaches, for supporting the deployment of resources, time and support.

Steps two, three and four comprise formation of policy steering committees and policy sub-teams (policy circles), including a senior trade union representative “buy-in”. Ferrer-Balas, Cruz and Segalàs (2006:27) state that institutional plans and decisions do not “happen” if there are no believers and actors.

Step five entails the creation of vision statement and guiding principles. The articulated and persuasive vision of the 1996 White Paper on S&T for the NSI that intends to drive national economic and social development (excluding environmental development), has not been adopted widely enough across the range of government departments to achieve the intended pervasive impact. Foxon, Makuch and Mata (2004:11-12) perceived the NSI and innovation governance as that which requires the formulation of a clear long-term vision and goals, the articulation of innovation as systemic processes, the advancement of the institutional and procedural basis for policy delivery and the incorporation of policy learning processes.

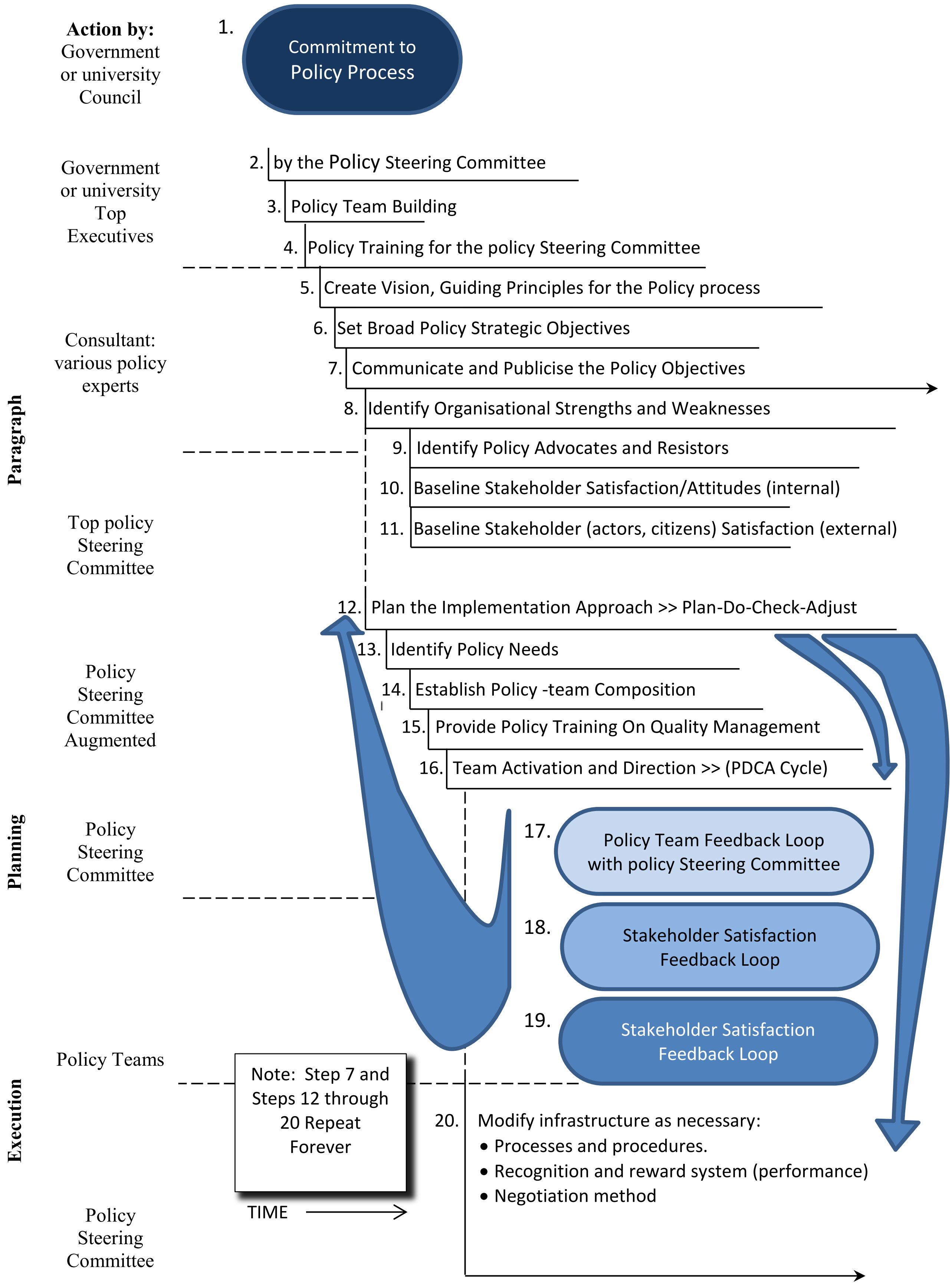


Figure 3.3-3: The Goetsch-Davis 20-step process
Source: Goetsch and Davis (2010:603)

Step six concerns the establishment of broad (strategic) objectives, which involves the development of policy objectives spelling out precisely the implementation route to be adopted.

The first of the five TYIP SA DST (2008:5) key principles states: "strategic decision: South Africa is failing to convert ideas into economic growth. While the government must invest throughout the entire innovation chain, strategic choices must be made". The selected policy objectives should be SMART, namely: specific, measurable, attainable, realistic and time-bound. Furthermore, implementation problems can stem from policy objectives, which may not be accepted by all NSI stakeholders.

Step seven consists of communication and publicity, which is meant to ensure that stakeholders are informed about the policy vision, the guiding principles and the objectives as well as avoids inaccurate policy related rumours spreading.

Step eight consists of the identification of policy strengths and weaknesses, which should be used to guide the policy cycle.

Step nine encompasses the identification of advocates and resisters, which requires building stakeholder "buy-in" to increase policy acceptance and implementation efforts.

Step ten and step eleven entail internal and external baseline stakeholder satisfaction respectively.

Step twelve incorporates the planning of policy monitoring and control implementation approach and in detecting bottlenecks and inefficiencies. The Deming plan-do-check-adjust (PDCA) cycle, illustrated in Figure 3.3-4, can be used during this step.

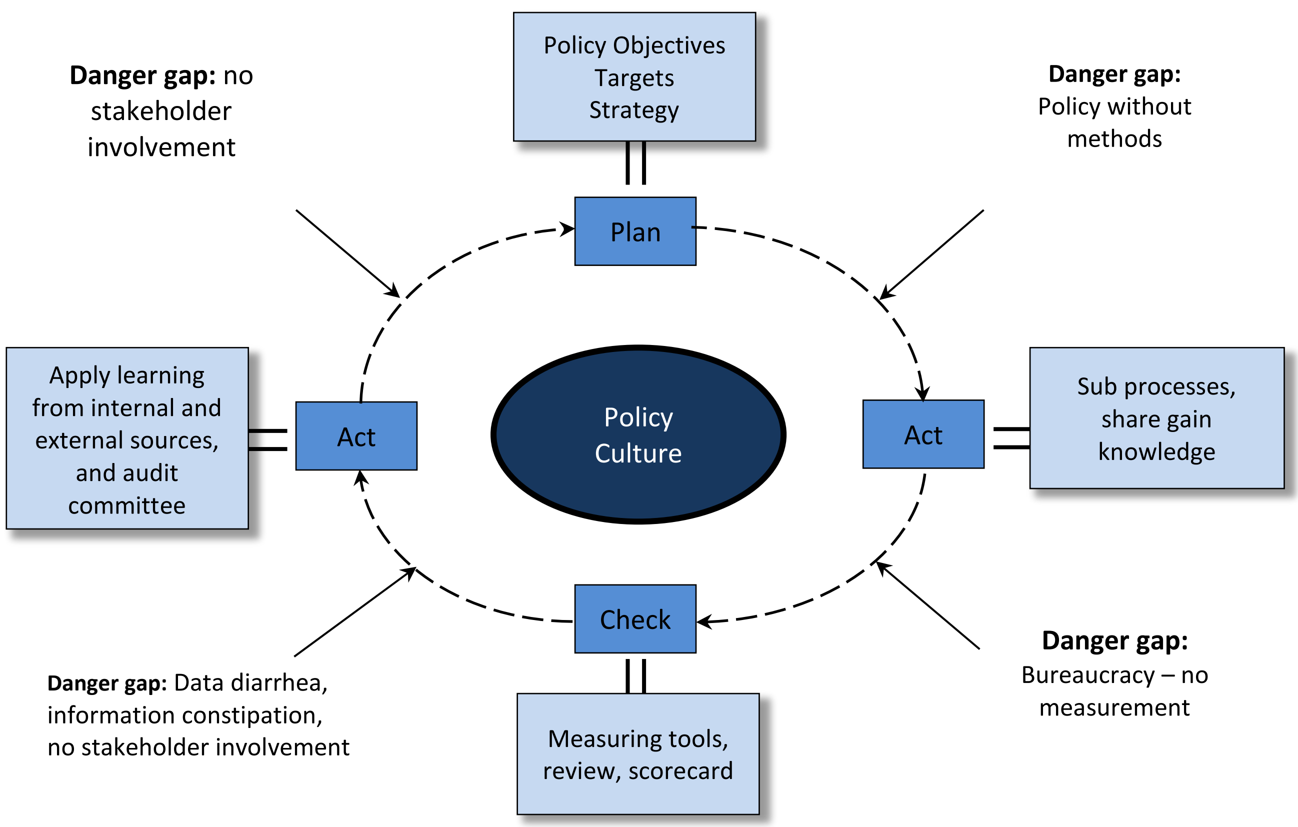


Figure 3.3-4: Mapping of the Deming continuous improvement cycle to policy process
Source: Adapted from Oakland (2000:255)

The PDCA cycle entails (i) ‘planning’ to achieve policy objectives fully; (ii) ‘do’ to implement the policy plans; (iii) ‘check’ that the anticipated improvement policy objectives are being achieved; and (iv) ‘amend/act’ to take corrective action and the cycle continues (Deming 2000:7). Veugelers et al. (2009:247) state that policy needs to be supported by analysis, M&E practices, which then feed back into the policy process. The PMI (2008:87) and Australian/New Zealand Standard ASNZS (4360:2009 2009) define control as the monitoring of specific policy results to determine if they comply with relevant standards and identifying ways to eliminate causes of unsatisfactory performance (Australian/New Zealand Standard ASNZS 4360:2009 2009). The National Research Foundation (NRF) is responsible for the monitoring of the evolution of new and significant fields of study and research, which is an important function and growth of the NSI.

Steps thirteen, fourteen and fifteen also involve policy monitoring and control. Fayol, the “Father of management theory” was the first to describe “control” as an important policy and management function of along with other functions which set out as being planning, coordinating, commanding, organising and controlling (Fayol, 1949; Chambers & Rand, 2010:116).

Step thirteen entails the identification of policy needs, which can collected from all South African citizens using an interactive process and strategy.

Step fourteen and fifteen involve establishing of a policy team, the team composition, training needs and policy quality issues.

Steps sixteen to twenty comprise the policy execution phase. Step sixteen specifically entails the formulation of policy direction, which can be aided by the PDCA cycle. Step seventeen to nineteen involve the policy committee providing a feedback loop, as well as undertaking stakeholders’ satisfaction the feedback loop which can be undertaken on monthly and yearly basis as part of policy monitoring and control. Step twenty involve modifying policy infrastructure, as necessary, guided by the feedback loop, which can be facilitated by policy infrastructure, procedures and processes, future and current policy structures, awards and recognition programs among other elements.

The next section entails a discussion of South Africa's NSI policy development.

3.4 SOUTH AFRICAN NSI POLICY DEVELOPMENT

This section examines South Africa's NSI policy development since the introduction of the 1996 White Paper of S&T, in particular by focusing on the NSI governance structures, institutional arrangements and resourcing patterns. The historical nature of literature on public policy has served to examine what has taken place since 1996 and where public policy is moving towards and what needs to be addressed and changed. For example, the literature review has shown that the planned and proposed institutional changes by various South African policy documents have not taken place. The literature review has shown that the planned and proposed institutional changes by various South African policy documents have not taken place. For instance, an innovation agency proposed by the OECD (2007b) Country Review has not been set up. Instead, the role of the NRF has been expanded to encompass innovation. Innovation programmes aimed at poverty reduction and the exploitation of South Africa's strong position in mature industries has not been launched.

The White Paper approved by Cabinet in 1996 established a policy framework for S&T in South Africa. The formation of the NRF in 1998, the NACI in 1998, and the DST in 2002 constituted the STI policy blueprint. A major development of STI in South Africa was the creation of two sources of competitive funds for R&D, the Innovation Fund (IF) in 1997 and the Biotechnology Regional Innovation Centres (BRIC) (2001). With oversight of the NSI as a whole, a Ministerial Committee on Science and Technology (MCOST) operated for several years from 1994, but then fell away in 2000. In 2002, National Research and Development Strategy (NRDS) under the responsibility of the DST were drafted. According to the SA DST (2002:64)

> Government will publish and annually update a three-year R&D Plan 'in sync' with the MTEF, capturing its R&D vision as well as key targets and investments. The R&D Plan will capture the programmes of each department, including the targets expected of parastatal institutions and the 'return on investment' expected from transfer payments. The strategy would be placed before Parliament on an annual basis." The governance role of the DST was defined in the 2004 New Strategic Management Model (NSMM) of policy on standards for science, engineering and technology institutions (SETIs).

At the highest level, the activities of the DST are overseen by the Parliamentary Portfolio Committee for S&T (comprising members of Parliament). The DST's primary function is the pervasive, systemic formulator and coordinator of NSI-related policy and strategy, allocating macro-resources, promoting system learning through the oversight of effective and integrated M&E, maximising international cooperation and resources, systemically overseeing public research organisations, and providing best-possible knowledge infrastructure (people, equipment and facilities, and cyber-infrastructure) within the public sector (SA DST Ministerial Review Committee, 2012:19). At Level 2, the NRF is the only sizeable agency in the system, in the sense that it deals with multiple programmes. The use of research councils/institutes is widespread at Levels 3 and 4, which receive a substantial grant from the responsible ministry and have a mandate both to set priorities for individual projects and to do research.

The 1996 White Paper on S&T seeks to stimulate the NSI, which is central to the empowerment of all South Africans in seeking to achieve social, political, economic and environmental goals as well as a problem-solving, multi-disciplinary, partnership approach to innovation as a mechanism of growth and development. In the global context, the 1996 White Paper seeks increased coordination of innovation policies and strategies in response to the complex challenges generated by global social and economic changes.

The 1996 White Paper attempted to ensure the "constructive interactions" between the Growth and Development Strategy of 1995 and the Macroeconomic Strategy of 1996 for the successful implementation of the broader policies. The principal NSI institutional stakeholders are made up of the central policy and line departments, government agencies, SETIs, private sector, higher education sector (HES), Non-Government Organisations (NGOs) (SA DST, 1996:22-26).

The 1998 system-wide MCOST reviews found that public sector institutions were characterised by poor interactions and networking, which constituted a major weakness of the South African SET system, with the major deficit between SETIs and the HEIs. The reviews recommended that a provision be made for system-wide independent oversight, evaluation and strategic advice to the government and that numerous opportunities should be provided to facilitate linkages and interactions across disciplines, sectors and institutions in order to create a stimulating environment and an innovative climate throughout the entire system. The National Research and Technology Foresight (NRTF) exercise published outputs in 1999, which were intended to put real content into the NSI and, thereby, develop a framework of goals within which the technology programmes can be shaped. The NRTF initiative was different from other NSI-related interventions. However, the immense effort of NRTF was not rewarded with take-up in line departments or even in the policy trajectories by the DST (SA DST, 1996:25-26).

In 2002, the government endorsed the DST's NRDS which made some of the institutional and governance proposals of the earlier White Paper more explicit, by identifying eight key weaknesses in the South African NSI (SA DST 2002:15): (i) the dramatic drop in Gross Domestic Expenditure on Research and Development (GERD), which fell from 1.1% of GDP in 1990 to 0.7% in 1994, and which had only slowly been recovering; (ii) the need to maintain and to generate national absorptive capacity; (iii) failure to renew human resources for S&T; (iv) declining investments in formal R&D by South African companies; (v) an inadequate infrastructure and legal system to handle IP; and (vi) fragmented governance structures in research and innovation funding.

The five missions of the NRDS (2002) are: (i) new Technology and Innovation Missions for the S&T System; (ii) core functions of technology and innovation missions; (iii) S&T for poverty reduction; (iv) technology and knowledge for and from resource-based industries; (v) and strengthened programmes to support innovation. There is a high degree of mismatch between identified strategic priorities and implemented programmes, with only the first two of the five aforementioned technology missions seem to have been developed and implemented. An R&D programme that was not part of the NRDS has been implemented on a larger scale than any of the priority missions of 2002, and probably with much larger cross-system effects.

The NRDS DST (2002:17) proposed that basic research is a key shared function of the DST and the Department of Education (DoE) and that the DST should, over time, create five cross-cutting institutions/agencies, illustrated in Figure 3.4-1.

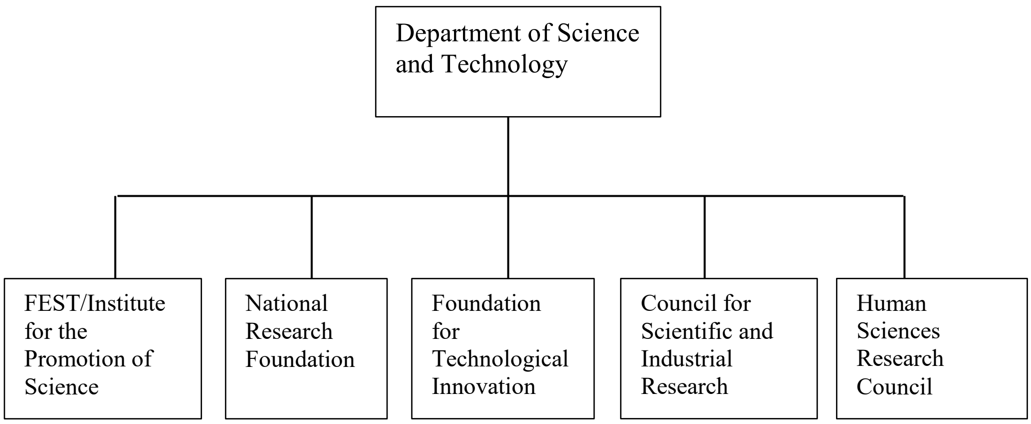


Figure 3.4-1: Five cross-cutting institutions of SA DST
Source: OECD (2007b:105)

The five cross-cutting institutions/agencies proposed by the NRDS Figure 3.4-1 are: the National Research Foundation: the FEST (later to become the Institute for the Promotion of Science), the Foundation for Technological Innovation, the Council for Scientific and Industrial Research (CSIR), and the Human Sciences Research Council (HSRC) (OECD, 2007b:105).

According to NGP document by EDD (2010) the (NPC), (2011a) and the SA DST Ministerial Review Committee, (2012:76) the recommendations of the NRDS 2002 have not been fully implemented. For instance, the poverty reduction programme and the programme for resource-based industries have not been implemented, resulting in significant missed opportunities to use research and innovation to support central social and economic development objectives. The SA

DST TYIP (2008) failure to transform the 'S&T for poverty reduction' a key Mission of the NRDS, (2002) into a Grand Challenge and appears to fly directly in the face of the recommendation of the OECD (2007b) to close the gap between the 'first' and the' second' economy.

The New Strategic Management Model (NSMM) organisational model was established in 2004 for the public sector SETIs because of significant failures in achieving SETIs objectives. However, no progress has been made to date and considerable resistance is being encountered to the current piecemeal approach.

The NRF is an agency of the DST and receives about half its income in the form of a core grant from the DST, and the balance via service contracts with the DST, the Department of Trade and Industry for Technology and Human Resources for Industry (THRIP), the Department of Labour (DoL) (for the Scarce Skills Development Fund) and the Department of Environmental Affairs and Tourism (for marine research). Figure 3.4-2 illustrates the organisational structure of the NRF adopted from OECD (2007b:118).

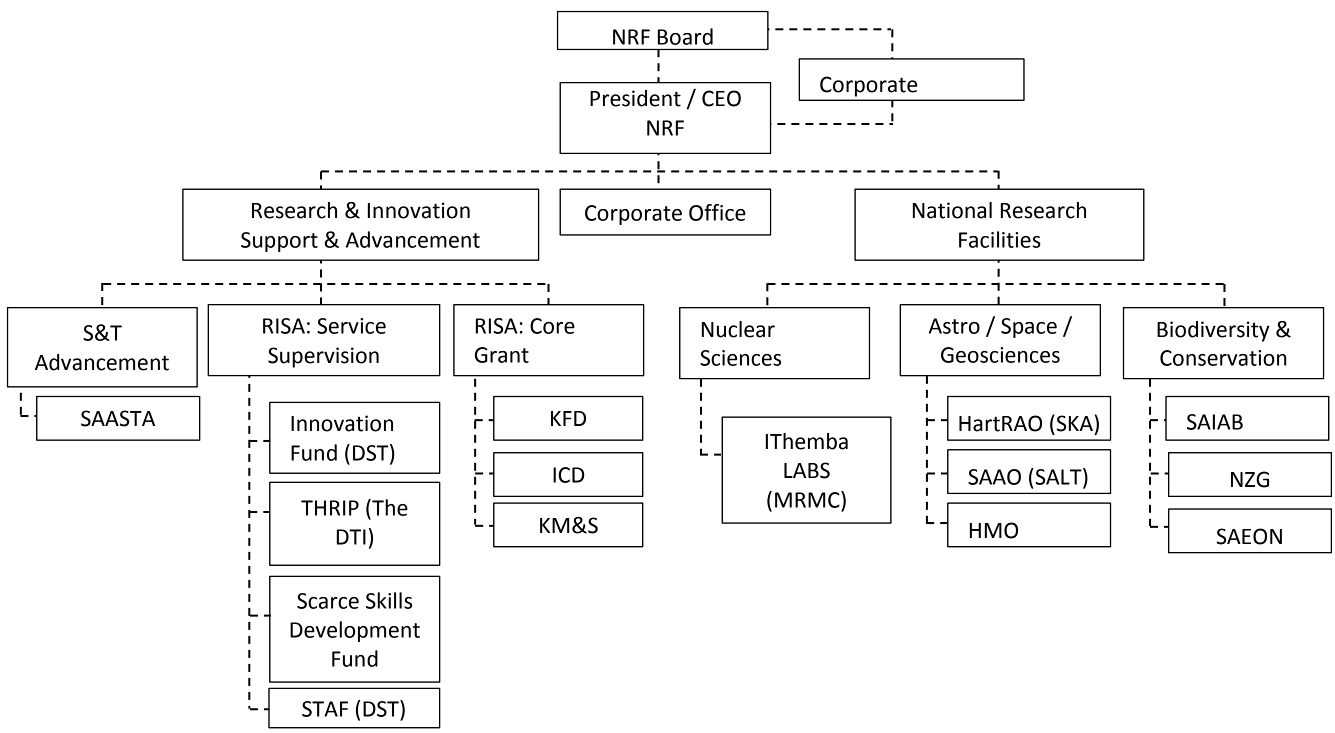


Figure 3.4-2: Organisational structure of the NRF
Source: OECD (2007b:118)

Prior to the OECD (2007b) Review, the NRF resource base had become too thinly spread across a wide range of activities. In response, the NRF has moved to rationalise the programmes under its control, including the Centres of Excellence, the Flagship Projects and the National Facility

clusters. The challenge remains to balance investment between the foundation disciplines and areas of strategic focus, including priorities identified in the NRDS and the Grand Challenges. The NRF funds mostly within nine broadly defined focus areas which are primarily thematic rather than disciplinary in nature and emphasise the link to social and economic application.
The CSIR was set up in 1945 and is by far the largest of the South African public research institutes (PRIs). The CSIR functions as the major national industrially-oriented research institute and is directly comparable to institutions such as Valtion Teknillinen Tutkimuskeskus (VTT) (State Technical Research Centre) of Finland, The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF) of Norway and Netherlands Organisation for Applied Scientific Research (TNO) of Netherlands. Although there has been a steady improvement in the quantity and quality of the CSIR's outputs (in the form of ST&T publications, patents among others), the biggest problem continues to be the breadth of its mandate, in that the organisation can be called on to do anything that may be said to have a 'technology' definition (Mashelkar, Leppävuori & Kaplan, 2003:12; OECD, 2007b:139). The SA DST Ministerial Review Committee (2012:76) notes that "it seems that the proliferated, fragmented and over-committed activities of the CSIR are a reflection of, among other things, a larger systemic failure to provide coordination for the NSI".

The HSRC was established in 1968, with the mission of undertaking, stimulating and promoting policy-relevant applied social science that contributes to development in South Africa. The research agenda of the HSRC is directly guided by national development priorities, as well as the UNDP MDGs (2010). The HSRC pursues strongly-structured programmes of research, which include large-scale cross-sectional and longitudinal research, as such the annual National R&D Survey and the Innovation Survey. The annual government lead R&D survey is a highly significant component of the NSI.

The Medical Research Council (MRC) was established in 1969 as a research facility of the Department of Health, which produces about 600 peer-reviewed journal articles a year and two to five patents. A patent for an invention is the grant of a property right by the government, which allows the patent holder to exclude others from "working" the invention: making, using, offering for sale, or selling the invention in the RSA or "importing" the invention (South African Intellectual Property Rights, 2008). The MRC has 47 research units organised into six categories and is the only one of the research councils to act as an R&D funding agency. However, the six categories have no leaders, are more descriptive than organisational and not reflected in the planning process.

Other agencies of the DST include the Indigenous Knowledge Trust to safeguard and exploit indigenous knowledge systems (IKS), the Meraka Institute for information and communication technology (ICT), the BRIC, the SA AIDS Vaccine Initiative, the SA Bioinformatics Initiative, the Automotive Industry Development Centre, the Innovation Hub, the South African Centre for Epidemiological Modelling and Analysis, the South African Malaria Initiative, and the S&T centres of Armscor. It is estimated that the total budget of the units was approximately R 700 million in the 2008/09 financial year. To this end, the next section presents a summary of OECD South African NSI country review.

3.5 SUMMARY OF OECD SOUTH AFRICAN NSI COUNTRY REVIEW

Origins of the OECD date back to 1960. As of 2013 the OECD consists of 34 member countries across the globe, excluding Africa, from North and South America to Europe and the Asia-Pacific region. OECD members include many of the world's most advanced countries, but also emerging countries like Mexico, Chile and Turkey. The OECD also works closely with emerging giants like China, India and Brazil and developing economies in Africa, for example South Africa, Asia, Latin America and the Caribbean. The OECD provides a setting where governments compare policy experiences, seek answers to common problems, identify good practice and coordinate domestic and international policies (OECD, 2013a). Some selected OECD member countries provide an international perspective with respect to the construct of SD based on commercialisation of research in the NSI.

The South Africa's DST commissioned the OECD in 2006/2007 to conduct a review of South Africa's NSI (effectively the innovation policy), which was the most comprehensive overview of the NSI since the SETI system-wide review of 1998. The OECD (2007b) Country Review utilised a well-developed and reliable OECD standard methodology, which in summary concluded that: (i) South Africa is advancing, but failing to fully achieve its considerable potential. Income inequality remains extremely high, educational outcomes are poor on average and hugely uneven, and frustration is growing with public service delivery failures and corruption. Practical details of the South African NSI have been often mapped out in ways that are somewhat narrow, with too much focus on the role of public R&D-performing institutions. The narrow focus has obscured important issues such as the central role of business enterprises in generating and implementing innovation (OECD, 2007b:15); (ii) the macroeconomic policy mix has been insufficiently supportive of growth, while allowing large budget deficits to persist. Much of the increase in spending came through large increases in the public sector wage bill, while public investment has fallen as a share of total expenditure. The interaction of weak competition in product markets and dysfunctional labour markets is holding back growth and aggravating unemployment; (iii) in the governance of research and innovation, South Africa appears to lag good international practice in at least two respects, firstly, the lack of research and innovation forum, which has been compounded by the normal difficulties of coordination across different ministries, despite the innovative use of clustering. Secondly, there is limited separation between customers and contractors in the public research system in line with the Rothschild principle of 1971, discussed later in the section; (iv) Education is a critical problem. Skill mismatches represent one aspect of the persistently high unemployment rate, especially for youth: the education system is not producing the skills needed in the labour market. Shortages of learning materials, teachers, support staff and well-trained principals across most of the school system are among the causes of poor outcomes; (v) the presence of bottlenecks or other failures that impede innovation processes can also constitute crucial obstacles to growth and development of South Africa's economy, justify state intervention not only to fund research, but more widely to ensure that the innovation system performs as a whole (OECD, 2007b:18). Some of the NSI South African failures identified by the OECD (2007b:18) include NSI capability failures, institutional failures, network interactions failures and NSI, (vi) the NSI is insufficiency to support a transition from strong reliance on a resource-and commodity-based economy to one that will be characterised by value-adding and knowledge-intensive activities (OECD, 2007b:9); (vii) the lack of formal horizontal and vertical co-ordination and integration resulting in cross-departmental issues (OECD, 2007b:231); (viii) little connection between the articulation of important technological and innovation priorities and subsequent implementation; (ix) the concept of a NSI had as yet gained limited currency, beyond the traditional R&D activities (OECD, 2007b:13); the associated gap in a wide range of design, engineering, entrepreneurship and management, institutionalisation of science, technology and innovation, which threatens the NSI functioning. The "engineering gap" is a looming crisis (OECD, 2007b:13); (x) lack of NSI innovation programmes aimed at poverty reduction (OECD, 2007b:128); (xi) Inconsistencies between immigration policies and the human resource needs of the innovation system (OECD, 2007b:11); (xii) The policy framework for addressing "green" issues, including climate change and water scarcity, is sound, but implementation has so far been slow, in part due to limited administrative capacity; and (xi) weak integration between national policy and support measures at the provincial and local levels. No formal response to the OECD Review of the NSI was ever made public. Most of the central recommendations of the OECD (2007b) Review were not addressed in the SA DST's TYIP (2008), especially bringing the private sector more centrally into the NSI and resolving the considerable vertical and horizontal coordination difficulties arising from the current governance and institutional architecture.

A follow-up analysis of South Africa by the OECD (2013:2) found that: (i) South Africa is advancing, but failing to fully achieve its considerable potential; (ii) the macroeconomic policy mix has been insufficiently supportive of growth while allowing large budget deficits to persist; (iii) the interaction of weak competition in product markets and dysfunctional labour markets is holding back growth and aggravating unemployment; (iv) education and skill mismatches is a critical problem. To this end, the next section is a review of South Africa's NSI innovation policy.

3.6 INNOVATION POLICY

This section reviews literature on the South Africa's innovation policy for SD within the NSI. The literature is used to assess the innovation policy reforms and implementation and the directions policy should take to become more systematic. The argument advanced in this thesis is that an innovation policy cannot compensate for seriously flawed framework conditions. The designated policy coordinator of the NSI, as a whole, is the DST, whereby on the one hand, is the private-sector and state-owned enterprises and on the other hand is the public HEIs and science councils, all of which are the key performers of research.

The proposal that government shapes innovation strategy and policy for socio-economic development has been supported by scholars and prominent organisations, such as, Buys (2004), OECD (2007a) and Soares and Podcameni (2014). The foundation of the NSI central policy matrix should be that of a clearly articulated and shared purpose, custom-designed organisational structures and dedicated resource flows (SA DST Ministerial Review Committee, 2012:87-88). Adapting from Edler (2009:6) the definition of 'demand innovation policy', an innovation policy refers to "a set of public measures to increase … innovations, to improve the conditions for then uptake of innovations and/or to improve the articulation of …[innovation] in order to spur innovations and the diffusion of innovations". Innovation policy is also about market creation, as governments can play a role by actively supporting breakthroughs (basic research, product standards, public procurement) (Lafferty et al., 2005:263). For the purpose of this research innovation policy has been defined according to the Finnish Country Review Commission (2009:13) "as a set of actions by public organisations that influence the development and diffusion of innovations".

Table 3.6-1 presents some important a national S&T policy, regulatory functions and executing mechanisms of the NSI. The innovation policy agenda requires a broader, cross-ministerial attention, greater interrelatedness of innovation systems and innovation policy is no longer simply the purview of S&T institutions (OECD, 2005d:17).

Table 3.6-1: Policy and regulatory functions and executing Mechanisms

POLICY AND REGULATORY FUNCTIONS	EXECUTING MECHANISMS
Mechanisms to formulate policies, and, in some countries, plans for S&T	Financing functions for research and for technological development
Organisations to gather, analyse and disseminate information, including statistical information	Mechanisms for evaluating and acquiring technologies
A capacity for forecasting and foresight, and for assessing the likely directions of technical change	Institutions to execute research Programmes
Capacities to regulate complex technologies	Mechanisms to link R&D outputs to practical use
Mechanisms for identification and protection of IP	Facilities for the education and training of S&T
Policies and programmes to maintain the vitality of the national S&T community	Mechanisms for the provision of technical services (such as, metrology, standardisation, calibration)

Source: IDRC (1993:20)

The South African DST performs a majority of the functions outlined in the White Paper on S&T (1997) and subsequent policy documents. The benefits of country's STI policies, including specific policy instruments, cannot be adequately assessed outside the specific context of the national innovation system for which they are designed (OECD, 2005a:7).

Innovation policies and governance are context-dependent (Tsipouri & Papadakou, 2005:13), for example innovation policies for SD (Moors & Mulder, 2002; Foxon, Makuch, Mata & Pearson, 2004; Smith, Stirling & Berkhout, 2005). From this perspective of this research, the dominant rationale for the South African NSI innovation policies should be defined in terms of the three pillars of SD. The science and innovation policy documents in South Africa include: (i) White Paper of S&T (1995 - 1996); (ii) Green paper (1996) (iii) National Research and Technology Audit (1997); (iv) SETI Review (1997); (v) NACI Act (Act 55 of 1997); (vi) DACST94-Foresight Study (1998 - 1999); (vii) NRF Act (Act 23 of 1998); (viii) NRTF study (2000); and (viii) NRDS (2002).

A number of other important strategies implemented by the South African policy makers include: (i) the National Skills Development Strategy for South Africa by the DoL in 2004; (ii) towards a Framework for the M&E of South African Higher Education by the DoE in 2004; (iii) Advanced

Manufacturing Technology Sector (AMTS); (iv) IKS Policy (DST, 2005); and (v) Nanotechnology Strategy and Higher Education Qualifications Framework (HEQF) by the DoE in 2004. In summary, this research supports the view that a viable national S&T policy should encompass: (i) the training of human resources at all levels; (ii) funding of R&D systems and institutions and networks; (iii) appropriate forms governance and accountability for the S&T institutions; (iv) healthy links among the NSI actors; (v) the stimulation of both radical and incremental change; (vi) establishment of a vigorous role for the research; (vii) the promotion of unimpeded flows of knowledge and information; (viii) effective integration of a government's S&T policies with other policies; and (ix) the management of overall policy strategy S&T (IDRC, 1993:20-21). The first two generations of innovation policy were linked to S&T as a linear process for innovation from basic research via applied R&D to market introduction of the resulting products or technologies. The second generation of innovation policy was based on the NSI approach and was basically developed through the 1990s (OECD, 2002a; 2005:18). In both the first and second generation codified scientific knowledge is seen as the basis for pull/demand and push/supply driven high-tech policy approach (Edquist, Luukkonen & Sotarauta, 2009:14).

The third generation of innovation policy involves a broader focus in which innovation is stimulated across a number of governmental or policy areas and builds upon the horizontal role of providing a strategic framework across ministerial and institutional boundaries (Lengrand & Louis, 2002:6). In the third generation of innovation policy, integrated, co-ordinated, strategic actions are critical for the development of coherent policy framework (OECD, 2005a:19).

In this research context, the third generation of innovation policy aims to ensure that the acquisition, application and adaptation of clean and efficient technologies for SD. However, the challenge is for South Africa to evolve from a traditional first-generation innovation policy to an explorative third-generation innovation policy.

The 'appetite for innovation' for South Africa should be fostered by well-designed and well-executed innovation policy, which should be well communicated. Figure 3.6-1 presents five different communication strategies that the South African government as the leading NSI actor, can use to communicate policies (SD, research and innovation) to other NSI actors, namely: (i) 'spray and pray'; (ii) 'tell and sell'; (iii) 'underscore and explore'; (iv) identify and reply, and (v) 'withhold and uphold'.

This study supports the ‘underscore and explore’ communication strategy where joint involvement and collaboration takes place in formulating and implementing [policy] change (Cornelissen, 2008:205). An open climate influences stakeholder’s trust, commitment and willingness to change (Poole & McPhee, 1983:11). Cornelissen (2008:113) recommend that the communication strategy and medium to be used should be ‘zero based’, rather than a pre-fixed standard that worked in the past.

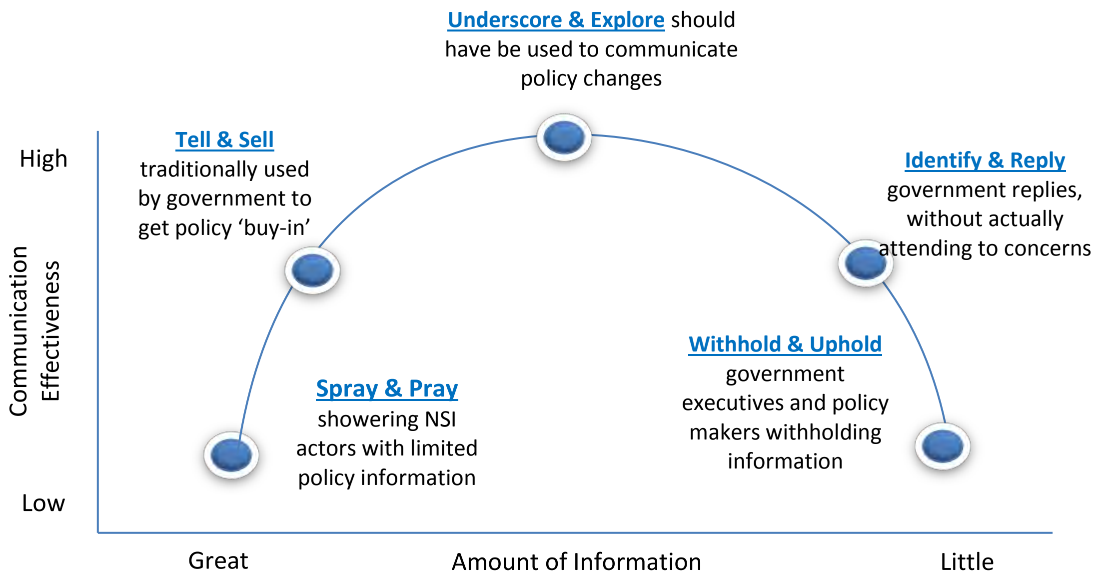


Figure 3.6-1: Exploration of five different communication strategies

Source: Adapted from Cornelissen (2008:96-118)

3.7 POLICY INTERVENTIONS

Early innovation strategies in Africa were influenced by the tensions between the revisionist approach, which favoured policies of state intervention (Stein, 1992; Griffin, 1996; Lall & Wangwe, 1998; Mkandawire & Soludo, 1999) and state-driven social (dependentistas) (Smith, 1979:248). On the contrary, the neo-liberal agenda (such as trade liberalisation and the deregulation of financial markets) has advocated minimising the role of government while focusing on “getting the fundamentals right” (World Bank, 1994; 2000; Rodrik, 2007; 2008).

In South Africa, deliberate and concerted framework conditions that shape the NSI includes policies and regulations for skills supply and immigration law, foreign exchange regulations, tax incentives, the regime for state loan finance, equity stakes and grants, and the protection of IP. This research contends that for the NSI trajectory in the upward direction to take place concerted policy interventions seeking synergies and forms of momentum to disrupt the current considerable inertia in the system are required. Given the existing infrastructural, structural, institutional and financial constraints, over reliance on a market system to self-correct can result in underinvestment in SD in South African research commercialisation in the NSI. The market limitations facing South Africa indicate the need for tailored, appropriate policy mix along the continuum between strict non-intervention and free market, one that minimises the government's role, while focusing on getting the fundamentals right. In this context, the DST 'own activist approach' should only take place as a result of market and systemic failure and not *vice versa*.

The reasons for public policy intervention in a market economy may be specified in terms of two conditions (Edquist et al., 2009): (i) private organisations prove to be unwilling (because of high risks or in ability to appropriate the benefits from the innovation) to achieve or unsuccessful in achieving the objectives formulated; thus, a problem exists; and (ii) the state (national, regional, local) and its public agencies have the ability to solve or mitigate the problem. From this research perspective, the South African innovation policy can be attributed to the (low) performance of the NSI and the resulting deficiencies in the key activities within the system.

3.7.1 Innovation Policy Evolution

This sub-section explores the various innovation policy models relevant for the construct of SD in South Africa through research in the NSI. Rothwell (1992), cited in Trott (2005:21-25-27), and O'Sullivan and Dooley (2009:47-51) present five generations of innovation policy models that that have dominated the field of innovation, presented chronologically in Table 3.7.1-1.

Table 3.7.1-1: A chronological development of models of innovation

GENERATION	EMERGENCE	MODEL	CHARACTERISTICS
First	Early 1950 to mid-1960s	Technology push	Simple linear sequential process; emphasis on R&D; the market is a recipient of the fruits of R&D
Second	Mid-1960s to early1970s	Market pull	Simple linear sequential process; emphasis on marketing; the market is the source for directing R&D; R&D has a reactive role.
Third	Early 1970s to early 1980s	Coupling model	Emphasis on integrating R&D and marketing
Fourth	Early 1980 to mid-90s	Integrated parallel model	Interactive model Combinations of push and pull
Fifth	Late 1990s	Integrated, networked model	Emphasis on knowledge accumulation and external linkages

Source: Adapted from Rothwell (1992) Trott (2005:21-25) and O'Sullivan and Dooley (2009:47-51)

3.7.2 The First Generation (Linear Model) Innovation Policy Model

The first-generation innovation policy model can be traced to 1945 Walwyn and Scholes (2006:242) also referred to as 'technology push' (Rothwell, 1992; Trott, 2005:22; O'Sullivan & Dooley, 2009:48). The linear model assumes that economic performance follows research performance (OECD, 2005c:352), on the basis of "research in, technology out" (United Nations, 2005; Bell, 2006).

In the 1980s the sequential hierarchical process and related conventional R&D policies were found to be ineffective (Trott, 2005:22; OECD, 2005c:250; Breznitz et al., (2011:95), pushing administrative reform further to support better policy co-ordination (OECD, 2005c:348). The persistence of the research-led linear model of innovation has been attributed to the South African NSI failure (SA DST Ministerial Review Committee, 2012:113). However, rather than just discarding the technology push model, this research supports the use of an interactive model, government mechanisms and innovation policies for generating innovation.

3.7.3 The Second Generation Innovation Policy Model

The second-generation innovation policy model of the mid-1960s referred to as 'demand pull, market-pull' or consumer(s) need-driven model resulted in the U.S.A Innovation Law of 1999 that provided a legal framework for extending R&D policy to an integrated innovation policy (Rothwell, 1992; Trott, 2005:23; OECD, 2005c:335). The model put forward that the marketplace was influential in the innovation process (Hippel von, 2005: Trott; 2005:23), while technology was demoted to an enabler role (O'Sullivan & Dooley, 2009:49). The term "driven" implies that demand and users influence the development and diffusion of innovations (Edquist et al., 2009:15). Both the first- and second-generation innovation policy model lead to the 'innovator's dilemma (Christensen, 1997:xxiii–xxiv) as neither offered an accurate description of how innovation actually occurs in real-life situation (Jovanovic & Rob, 1987). In Breznitz et al. (2011:71) terminology "there is nothing in the logic of innovation that leads to emphasising the supply of or the demand for novel ideas…the two sides are complementary". As a result the two models have not survived empirical scrutiny, because innovation has been viewed as a linear unconnected phenomenon modular (Rothwell, 1992). Therefore, in this research context, policy-makers should appreciate that innovation never happens either by push or by pull, but rather, as a complex reciprocal mechanism.

The 'push' and 'pull' innovation policies, inputs measures have been identified with R&D expenditures, while output measures have included counting patents and scientific publications

(OECD, 2002a, 2007b; UNIDO, 2011). Nevertheless, the technology push" and "demand pull", linear models cannot be literally ignored. According to Hippel von (2005;2007:295-300), in Africa innovation strategies have traditionally been driven by supply side policies, with little regard to the role of demand in shaping innovation strategies. Demand from users can also influence the nature and the direction of innovation.

3.7.4 The Third Generation Innovation Policy Model

The third-generation innovation policy, also referred to as the simultaneous coupling of holistic model, emerged in the early 1970s, and was driven by economic stagnation and increased competition as a result of the oil crisis and the inadequacies of the first two models (Trott, 2005:23; O'Sullivan & Dooley, 2009:49). The simultaneous coupling model promoted 'technology-push' model and 'market pull' as opposite ends of spectrum that required significant interaction and trade-offs between the two extremes (O'Sullivan & Dooley, 2009:49). In this research context, the third innovation policy model supports an integrated strategic S&T objective, both vertically and horizontally, which is relevant for achieving SD objectives within the NSI.

3.7.5 The Fourth Generation Innovation Policy Model

The fourth generation innovation policy model also referred to as the interactive model emerged during the economic resurgence of the mid-1980s and was strongly influenced by the practices of Japanese industry. The model was more holistic and integrated that simultaneously brought together the technology-push and market-pull models (O'Sullivan & Dooley, 2009:50). The interactive model is relevant to-date as it revolves around organisational functions of R&D, engineering and design, manufacturing and marketing and sales.

3.7.6 The Fifth Generation Innovation Policy Model

The fifth generation model can be viewed as an extension of the fourth generation, where greater focus is placed on networking, system integration, and agile communications infrastructure (OECD, 2005c:335). The model also emphasises the importance of interaction (both formal and informal) within the innovation process (Nonaka & Takeuchi, 2005:21-25).

3.7.7 Schumpeter I Innovation Policy Model

Another perspective to innovation models is provided through a distinction of three historical innovation models of innovation in the literature, which Phillips (1971) and Fuglsang (2008) for example refer to as Schumpeter I, II, and III. Schumpeter I model of innovation revolved around the entrepreneur and was relevant at the beginning of the twentieth century when economic development was dependent on entrepreneurial individuals. Entrepreneurial activities were viewed as the source of innovation by Schumpeter's 1911 work, detailed in Schumpeter (1969).

3.7.8 Schumpeter II Innovation Policy Model

Schumpeter II model was relevant around the Second World War, when the state and enterprises invested in R&D on a large scale. In Schumpeter II (Schumpeter, 1947:1969), innovation is seen as being organised around R&D laboratories in large enterprises or within the state by trained specialists, researchers and engineers. Schumpeter I and Schumpeter II models presented innovation as a linear phenomenon where each aspect was considered modular and unconnected to other parts of the innovation process.

3.7.9 Schumpeter III Innovation Policy Model

Schumpeter III refers to innovation as an open and interactive process that involves many internal and external sources and ideas from various types of actors (Lundvall, 1992; Bessant, 2003; Hippel von, 2005; Chesbrough, 2006; Hippel von & Jin, 2009). The open innovation model has become more relevant in later years as innovation resources have become more distributed across organisations (Fuglsang, 2008:48). In this research context, Schumpeter III, model appears to be more relevant for SD in South Africa through research in the NSI.

3.7.10 The Ten Year Innovation Strategy

The South Africa TYIP (2008-2018), is the latest innovation policy for the NSI. According to the DST (2008:2-3), the knowledge-based economy rests on four interconnected, interdependent pillars: (i) innovation; (ii) economic and institutional infrastructure; (iii) information infrastructure; and (iv) education. The TYIP and the NRDS identifies key strategic areas for priority research, development and innovation for South Africa as shown in Table 3.7.10-1.

Table 3.7.10-1: Priority areas from the Ten-Year Innovation Plan and NRDS

TEN-YEAR INNOVATION PLAN	RESEARCH AND DEVELOPMENT STRATEGY
• Bio-economy • Space science • Energy security • Science and technology for global change • Human and social dynamics for development	• Science and technology for poverty alleviation • Advanced manufacturing • Technologies for resource-based industries • ICT • Nanotechnology

Source: Collated from South African Department of Science and Technology (2011:34)

From the international context, among the strategic priorities are five of what are known as National Critical Technologies: (i) Next-Generation Super Computer (ICT); (ii) Ocean and Earth Observation System (Environment; Social Infrastructure; Frontiers); (iv) Space Transportation System (Frontiers); X-Ray Free-Electron Laser (Nanotechnology/Materials); and Fast Breeder Reactor (FBR) cycle technologies (Energy) (Stenberg & Nagano, 2009:50).

The TYIP is designed to steer the resource-based economy towards a knowledge-based economy, by overcoming five main 'Grand Challenges'; namely: (i) the Farmer to Pharma value chain to strengthen the bio-economy; (ii) space S&T; (iii) energy security; (iv) global-change science with a focus on climate change; and (v) human and social dynamics. In this research context, the shift will have to include a diversification from South Africa's traditional reliance on the minerals and energy complex, reconfiguring the manufacturing base and indeed all human activities towards a green economy.

However, this research notes that the TYIP did not include poverty elimination as one of the 'Grand Challenges'. Rather, in mentioning the SA TYIP (DST, 2008:5) states that "the government's investments in S&T also help to eliminate poverty". The OECD (2005b; 2007b) supports the contribution of knowledge-intensive sector for Innovating 'Out of Poverty'. According to the SA DST Ministerial Review Committee (2012:23), the NSI also appears to be inadequate in its contribution to alleviating poverty and providing jobs.

Nevertheless, from this research perspective the TYIP draft sends a strong signal to the public of the government's commitment to building a comprehensive and sustainable research sector in support of a knowledge economy. Creative metaphors, such as "organisational learning" or "continuous improvement," can be used to assist the [NSI actors] members visualise the new paradigm (Sackmann 1989:466).

The new paradigm is characterised as the transition from a "control-based" to a "commitment-based" system (Cummings & Worley, 2001:258). Kuhn (1962:23) defines a 'paradigm' "as a set of assumptions, theories and models that are commonly accepted and shared within a particular field of activity at a point in time". From this research context, the shift will, by definition, involve a discontinuous and restructuring of the NSI. Some studies such as Edwards and Lawrence (2006), Arora and Ricci (2006), Lorentzen (2006), Rodrik (2006) and Altman (2007) have expressed the importance of a dual strategy in South Africa. This research views the STI policy as an important part in undertaking a dual strategy, which should involve supporting both resource- and knowledge-based economy to achieve South Africa's SD in LDC through research based on the NSI objectives.

Table 3.7.10-2 outlines South Africa's vision in the knowledge economy and indicators of achieving the plan. Thoms and Kerwin (2004:1018) define a vision "…as a cognitive image of the institution that is positive enough to followers to provide motivation and elaborate enough to provide direction for planning and goal setting." Communicating a positive vision is a common thread between the various leadership theories, namely: the contingency and universal theories.

Table 3.7.10-2: Innovation towards a knowledge-based economy: the transformation

INDICATOR	MEASURE	2018
SA positioned as knowledge based economy	Economic growth attributable to technical progress (10% in 2002)	30%
	National income derived from knowledge-based industries	>50%
	Proportion of workforce employed in knowledge-based jobs	>50%
	Proportion of firms using technology to innovate	>50%
	GERD/GDP (0.87 in 2004; short-term 2008 target was 1%)	2%
	Global share of research outputs (0.5% in 2002)	1%
	High- and medium-tech exports/services as a percentage of all exports/services (30% in 2002)	55%
	Number of South African-originated US patents (100 in 2002)	250
Research and technology enablers	Matriculates with university exemption in math and science (3.4% in 2002)	9%
	SET tertiary students as percentage of all tertiary students	30%
	Number of PhD graduates per year (963 in 2002)	2 200
	Gross availability of SET graduates to economy (235 438 in 2002)	450 000
	Number of full-time equivalent researchers (was 8 708 in 2002)	20 000
	Total researchers per 1 000 people employed	5%

Source: DST South Africa (2008)

Thoms and Kerwin (2004:1015) define leadership as the process of influencing others to understand what needs to be done and how it can be done. In this research context, dealing with the "wicked" challenges will require a model of leadership and conditions that will foster NSI collaboration. The SA DST Ministerial Review Committee (2012:84) states that "it goes without saying that a weakness in the area of sound and strategic management information will continue to hamper efforts to provide a coherent and coordinated NSI", which remains the overarching objective of this research. Therefore, NSI leadership will have an effect on achieving the vision outlined in Table 3.7-3. Similarly, Kaplan (2011) maintains that the DST has very few staff with any knowledge of business, with the situation mirroring the DTI's IPAP, which shows limited understanding of the importance of the science component of the research and innovation system.

According to the DST (2008), PhD graduates, either as staff or as post-doctoral fellows, will be the dominant drivers of knowledge production; HEIs should produce more than 100 PhD graduates per million of the population. Furthermore, the DST (2008) argues that it is essential to increase the number of African and women postgraduates, especially PhDs, to improve research and innovation capacity and normalise staff demographics. Since 1994, some of the transformation has been achieved as indicated by the ten year innovation policy of 2008. However, this research notes the number of African, female and disabled postgraduates still lag behind.

Some of the major constraints facing the realisation of the TYIP 2008 include: (i) the stuttering pipeline of knowledgeable, skilled and trained and human resources at all levels of the NSI; (ii) the inadequate investment in the existing research framework and sites; (iii) inability to keep up with the required knowledge infrastructure; and (iv) inability to incentivise private investment in innovation, both within and from outside the South African economy (OECD, 2007b:9-18). Within the South African NSI, both immigration policies and IP regimes need to be judiciously calculated to enable systemic openness for planned and fortuitous chemistries of innovation (SA DST Ministerial Review Committee, 2012:130). Notably, this research identified that the TYIP appears as more of a proposal, rather than a strategic plan to be implemented. Edquist et al. (2009:6) suggest that a 'strategy' consists of five dimensions namely: (i) a plan, in which a vision, goals and adequate measures are presented; (ii) legitimate forum for cooperation; (iii) a way to raise collective awareness and create shared lines of action and thought; (iv) the means of communication; and (v) the trigger for new processes. In addition, according to the SA DST Ministerial Review Committee (2012:62), the TYIP (2008), as originally disseminated, read more as an elaborate 'vision statement' than a fully developed action plan. In adopting Edquist et al. (2009:21) terminology the TYIP can be viewed "as a strategic plan, the new innovation strategy is conceptually fuzzy and, it does not contain a clearly articulated vision, strategy, and adequate measures for the future. The conceptual fuzziness is reflected in a whole variety of interpretations of its meaning and significance". The SA DST Ministerial Review Committee (2012:70) recommends that the mismatch between the intentions of the NGP, the TYIP and the Twelve Outcomes of government and their associated Delivery Agreements can be addressed through the establishment of the National Council on Research and Innovation, along with the Industrial Research and Innovation Funds, where the more detailed work of specifying demand, ensuring supply, and allocating resources will be articulated. The degree of mismatch between identified strategic priorities and implemented programmes suggests that the South African government should revisit the National Strategy and consider the effectiveness of existing coordination and NSI governance mechanisms. Revisiting the 2002 South African government strategic priorities might appropriately be located in the tradition of the South African innovation system perspective, which should commence from innovation strategy, rather than R&D strategy.

Nonetheless, the notion of the five 'Grand Challenges' discussed in the SA DST TYIP, (2008:11-24) has entered the discourse of the NSI community, especially the science councils. The TYIP, however, does not directly address the structural challenges of achieving the five Grand Challenge outcomes which, according the SA DST Ministerial Review Committee (2012), has been occasioned by the lack of systematic authority invested in the DST and NACI. The DST is also unlikely to achieve some of the outlined output targets for a number of reasons, the main one being the lack of alignment within government structures (National Advisory Council on Innovation (NACI, 2010:9). Oakland (2000:245-255) recommends instituting 'change programmes' by concentrating on 'process alignment', rather task alignment. The proposed knowledge-based economy will entail the use of 'active' systems that have clearer targets, policies, well-coordinated rather than 'passive' systems for the structural transformation to be effective (Viotti, 2002:655). This research is of the view that the TYIP transition should be managed carefully, through aligning SD, research and innovation policies for the growing knowledge economy as the key mandate of the South African government. Undertaking periodical research will promote the basis for benchmarking South Africa's performance in the knowledge economy transition.

South Africa can usefully establish a Nordic-style innovation agency (discussed in later Chapters) to realise the TYIP. Characteristics of Nordic agencies include (i) an innovation systems approach, for explicitly tackling institutional development, both in industry and in the knowledge infrastructure; (ii) technically and scientifically qualified staff in project and NSI programme management functions; (iii) strong internal strategic intelligence and dense networks with industry and the knowledge infrastructure for bottleneck analysis and programme design; and (iv) correspondingly, a strong *de facto* role in strategy and portfolio development within the responsible ministries. This research now turns to the literature review of SD policies mainly from a South African perspective.

3.8 SUSTAINABLE DEVELOPMENT POLICIES

This section reviews literature on SD policies within the NSI. In South Africa not only has innovation moved to centre-stage in the last decade in policy making, but there is a realisation that a co-ordinated, coherent, "whole-of-government" approach is required (OECD, 2007b:5). Globally, innovation policies have not been efficient until the last decade (Sutz, 2007:340). This research argues that commencing with SD policies approach can be as an important starting point for addressing innovation policies. In this research context, SD policies should be closely integrated with innovation policies right from the onset in order to achieve extensive and desirable outcomes. This approach does not mean a neglect of the general STI policies. An overview of South Africa's SD (economic, social and environmental) policy initiatives since 1994 indicates that the country's expectations have not been fully met and need to be addressed.

A SD policy combines economic, social and ecological goals and shares a holistic paradigm with third-generation innovation policy (Lafferty et al., 2005:255). Sustainable development policy objectives are normally better achieved by voluntary acceptance and compliance (the carrot approach) (De Coning et al., 2011:16). In South Africa developmental activities are largely informed by legislation and other policy documents such as White and Green papers, National Plans and S&T policy initiatives, such as the NACI Act (No. 55 of 1997), the Accelerated and Shared Growth Initiative, ASGI-SA, the R&D Strategy and the National Framework for Sustainable Development (NFSD).

This research supports the notion that SD initiatives require measures to: (i) build and strengthen a sound policy cycle in every policy sector (vertical coherence and policies); (ii) improve the co-ordination of sectoral policies (horizontal coherence and policies); (iii) allow for the modulation of short-term and long-term objectives (temporal coherence) and improve functional interventions, intended to improve markets operations without favouring particular activities (Lall & Teubal, 1998:1371-1380; Lafferty et al., 2005:261).

3.8.1 Historical Perspective on South African Sustainable Development Policies

In 1994, the new government adopted the Reconstruction and Development Programme (RDP) as the basic developmental policy framework. The RDP identified economic policy strategies across a wide range of issues and sectors, including macroeconomic policy, but by late 1995, the RDP's limited growth and employment impact was generally inadequate.

In June 1996, the macroeconomic policy, the Growth, Employment and Redistribution (GEAR), strategy was formulated. It focused on stabilising the foreign exchange market and on growth. Although successful in achieving many of the macroeconomic targets (such as containing the fiscal deficit), GEAR's initiatives did not succeed in reaching the explicit targets of 6% annual growth and 500 000 new jobs by 2001. As of 2001/02 there had been a shift from fiscal austerity to more growth-oriented policies in South Africa. The new Accelerated and Shared Growth Initiative South Africa (ASGISA), launched in 2006 was intended to address growth-oriented policy objectives, such as halving poverty and unemployment by 2014, with an average growth rate of 5% a year over ASGISA's ten-year horizon.

3.8.2 National Strategy for Sustainable Development

The NFSD was approved by Cabinet in 2008 and the National Strategy for Sustainable Development and Action Plan, referred to as NSSD1 (2011–2014), in 2011. South Africa's NSSD1 aims at strengthening existing planning frameworks by lengthening the time horizon and identifying long-term trends that could influence (positively or negatively) the intended outcomes for SD. Implementation of the NSSD1 is expected to be coordinated through established government structures. A key NSSD1 priority area is creating sustainable economies, with the objective of: fostering employment creation and anti-poverty projects with an emphasis on livelihoods derived from sustainability priorities such as waste recycling, alternative fuel production, solar and wind-based business opportunities, urban agriculture, local craft production, and biodiversity.

The NSSD1 (2011-2014) has three phases. Phase one aims at ensuring the rollout and successful implementation of the NFSD. This planning stage will require a clearly defined plan, which is well structured, properly coordinated and managed, and meets certain set out criteria. Efficient implementation of a strategic SD plan will involve securing interconnection with other policy documents (Hřebík et al., 2006:53-54). An international benchmarking by the NSSD1 (2011-2014) shows that it is important to integrate and align efforts to implement the NFSD with macroeconomic policies and programmes to avoid a situation where the NFSD is pursued as a separate issue.

Phase two of the NSSD1 (2011-2014) aims at: (i) formalising and consolidating institutional framework; (ii) compiling a status quo report of progress to date with performance in respect of implementing MDG targets nationally; (iii) finalising the national strategy and develop an action plan for the strategic priority areas; and (iv) mobilising and leveraging resources for implementation.

Phase three of the NSSD1 (2011-2014) will include: (i) engaging in sector policy reviews with the aim of identifying gaps and opportunities in the current policy; and (ii) improving the performance of the state through streamlining various cooperative governance structures; and (iii) ensuring that M&E processes are established.

3.8.3 The National Development Plan

The National Development Plan (NDP) Vision 2030 by the NPC (2011b) is a framework to accelerate economic growth, eliminate poverty and reduce inequality. The plan aims to reduce the costs of living and of doing business, resulting in improved consumer and business confidence, rising levels of private investment, and higher growth and employment. The NDP is a comprehensive and thoughtful blueprint for a prosperous, safe, democratic South Africa in 2030, with a detailed diagnosis of the many policy challenges.

The South African government has also embarked on a National Growth Path, NGP (EDD, 2010), a long-term project that supports rigorous policy intentions and interventions for constructing an inclusive developmental state. The NDP notes that "the [NGP] and this plan are complementary in the effort to lower costs in the economy, especially as high costs contribute towards limiting employment growth and increase hardship for poor households." The NGP differs from NDP because it has a somewhat more interventionist slant, with a greater emphasis on industrial policy. The NGP is an economic framework for the period 2010-20. The NGP, unlike the NDP, assumes a "job engineering" approach. A developmental state is one that "authoritatively, credibly, legitimately and in a binding manner is able to formulate and implement its policies and programmes" (The United Nations Economic Commission for Africa, UNECA, 2012:95; National Planning Commission (NPC, 2011a:340). The South African NSI is central in realisation of the NGP and NDP Vision 2030, which will require installing proper governance within the NSI. To this end, attention now turns to the literature review on policy indicator mainly from a South African perspective.

3.9 POLICY INDICATORS

This section undertakes literature review on policy indicators with respect to the construct of SD in South Africa as a consequence of research commercialisation in the NSI.

According to OECD (2007b:75), specific policy measures can be used to address specific market or systemic failures that hamper research and innovation. The concept of balance scorecard (BSC) approach for recognising value indicators was introduced by Kaplan and Norton (1992:72), with four elements: financial; internal business; innovation and learning perspective; and the customer perspective. The BSC was adopted in the South African science councils in 1998 and continues to form the base of performance compacts in the council respective accounting authorities. Critical success factors (CSFs), criteria that can be utilised for SD in South Africa through research in the

NSI have been outlined in Table 3.9-1. Various NSI actors ranging from government, HEIs to the business sector have in place CSFs and accompanying key performance indicators (KPIs) for monitoring performance and evaluation.

Table 3.9-1: Critical success factor criteria for the policy development and implementation

SAMPLE POLICY DEVELOPMENT AND IMPLEMENTATION SUCCESS FACTORS		
1. Institutional capability 2. Benchmark identification 3. Investing in people satisfaction 4. Input/output factors 5. Process improvement reviews 6. Risk management strategies 7. Self-assessment of sectors and government's departments	8. Technical capability 9. Recognition 10. Preferred country in African continent 11. Deployment of the policy 12. Devolving of the policies	13. Dependencies 14. Process quality 15. NSI partnership, 16. Government Procurement improvement 17. Cost reduction 18. All success factors combined

Source: Prepared for this research

The KPI criteria include developing a policy mission, objectives, plans and core processes to be achieved as illustrated in Figure 3.9-1 adapted from Oakland (2000:26).

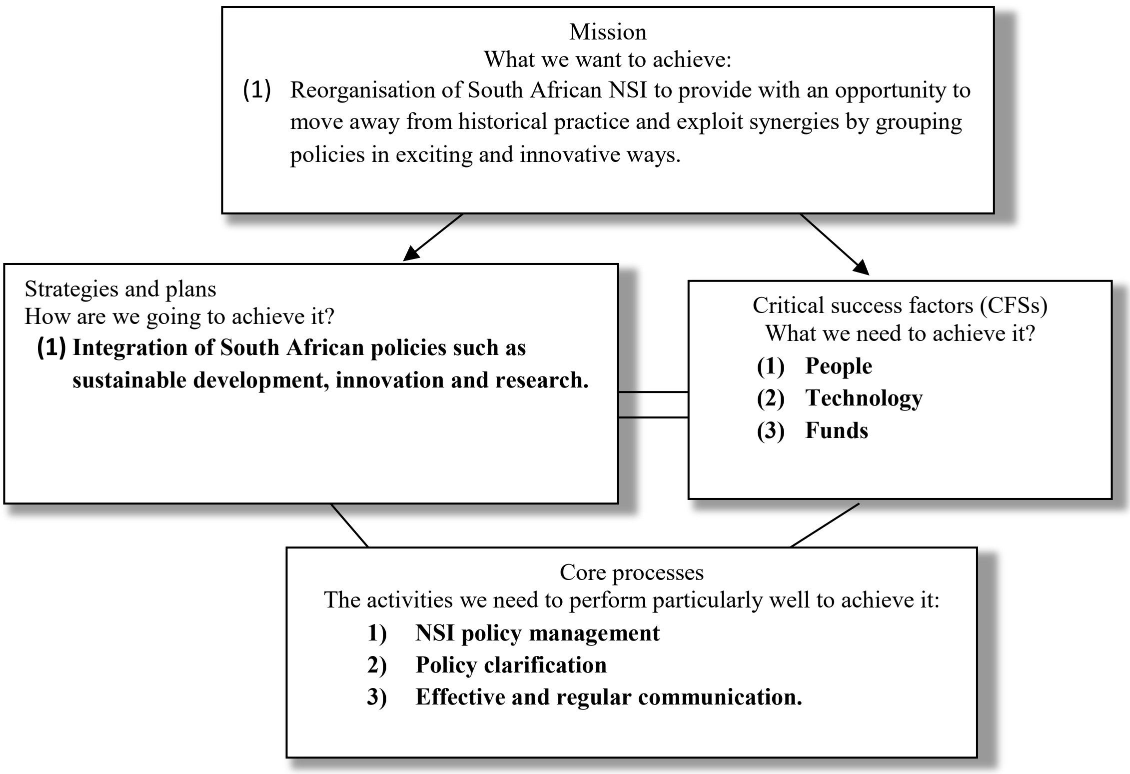


Figure 3.9-1: Turning the policy mission into action CSFs and core processes
Source: Oakland (2000:26)

In this research context, both Table 3.9-1and Figure 3.9-1 can be used for policy modelling to provide a tool and a methodology for successful policy or programme outcomes. Despite the NSI evaluation and monitoring constraints facing the South African science councils, the BSC is structured to capture both quantitative and qualitative KPIs (Pennypacker, 2006:305). Table 3.9-2 presents some prospective measures and indicators that can be utilised by the policy committees.

Table 3.9-2: Prospective measures and key performance indicators

PROSPECTIVE MEASURES AND INDICATORS	
General measures • Requirement policy performance • Lesson learned implemented • Policy stakeholders' satisfaction • Policy status communication • Leadership capability • Policy risk management • Policy training satisfaction	**Cost measures of policy outcomes** • Policy cost • Return on Investment (ROI) • Cost of capital • Produce cost variance plan • Policy start-up costs • Market share of innovation • Resource utilisation
Timing measures • Predictability of delivery • Policy timing • Policy planning • Policy cycle time • Successful policy phase exists	**Productivity measures** • Policy milestone performance • Alternative assessment • Policy success rate • Policy process improvement • Capacity/resource planning

Source: collated from Pennypacker (2006:305)

The KPIs enable the councils to detect policy changes resulting from science council research. The measures in Table 3.9-2 can be used to construct a scorecard that can be applied in the NSI policy management processes. However, the key BSC and KPI potential challenge is stated by the SA DST Ministerial Review Committee (2012:84) that "the BSC system constitutes a potentially rich source …, but the extent to which attainment of KPI targets attracts reward or sanction is unknown, as is the impact of the BSC" in South Africa. The next section undertakes literature review on research and knowledge policies within the NSI.

3.10 RESEARCH AND KNOWLEDGE POLICIES

This section undertakes literature review on research and knowledge policies with respect to the construct of SD in South Africa through research in the NSI. It further provides a theoretical focal point for demonstrating the importance of research and knowledge policies in South Africa, which can potentially generate more effective strategic NSI policy responsiveness and outcomes. In this research context, the important role of research and knowledge policies relates to the ability to provide practical strategies for creating and strengthening nodes and linkages for knowledge flow and exploitation to achieve the desired outcomes in South Africa. Furthermore, the South African government plays an important role in establishing the conditions for research and knowledge-driven economy. The expansion of research capacities is central for the advancement of knowledge and innovation. Sharing similar views with Foray (2010:97-100), this research acknowledges that policy can provide three dimensions namely: (i) encouraging the NSI actors (knowledge producers and assimilator) to engage in trial and error process of resource allocation and capacity development; (ii) ensuring that the knowledge ecology has diverse research expertise and; (iii) stimulating, rewarding, regulating, reinforcing connections and transforming knowledge ecology into adaptive innovative systems. This research defines knowledge ecology, according to David and Metcalfe (2008:34), as involving all kind of organisations and institutions dedicated to the production, dissemination and utilisation of new and superior knowledge. The next section reviews SD policy challenges facing South Africa.

3.11 POLICY CHALLENGES

This section contributes to the literature on how to foster an effective NSI policy. Literature review has shown that the governance of SD presents an enormous, but unavoidable challenge. The South African government faces a number of challenges in reformulating and governing innovation policies, which include: (i) identifying path dependencies and inherent biases in priorities; (ii) responding to new challenges with appropriate policy agenda and; (iii) learning about implicit priorities from broader policy or development models. However, continued unsustainability is not a viable option. Dealing with the policy problem will require the South African government to undertake policy experimentation in order to achieve policy coherence. Lack of proper policy integration and coherence is a major cause of policy failure (Archibald, 1988:89; Jolivet & Navarre 1996; OECD, 2005c:11). There are many barriers to overcome to create a new governance structure for better integrated policy cycles (Srininvas & Sutz, 2008; Rodrik, 2008; Chaminade, Vang, Lundvall & Joseph, 2009). In dealing with policy challenges, Edquist and Hommen (1999:76) state that:

> The use of 'development blocks' analysis can enable policy makers to discern and evaluate transformation problems between the [South African NSI actors'] …Policy may also have to fill such gaps in a way that will both stabilise situations and open up new possibilities for development.

Some tensions cause less policy coherence and less effectiveness in South Africa. These include: (i) rationales that are competing for individual policy domains have differing drivers of policy formulation and implementation; (ii) short-termism in resource allocation, budgetary practices often promote short-term thinking and in some cases undermine strategic long-term policy making include (OECD, 2005c:7). In South Africa, resources for action differ; (iii) strategic issues in new public management (NPM) regimes, which have led to significant efficiency gains in policy implementation (OECD, 2005c:8). However, the long-term co-ordinated political action within the NPM has been difficult; (iv) different imperatives for different policy areas possess a serious challenge in an attempt to adopt an integrated policy consisting of economic, social and environmental perspectives; (v) perceived division of labour between policy areas and “silos” policies and effects has resulted in frequently contradicting aims and inconsistent policy objectives within the NSI framework (OECD, 2005c: 31); (vi) fragmentation and segmentation, which often occur through new policies and institutions rather than major overhauls of the system, thus adding to the existing complexity within the NSI. Innovation policy may stimulate growth in certain industries, such as in knowledge-based economy, while at the same time leave or reinforce significant structural problems involving high levels of unemployment (Hayrinen-Alestalo & Pelkonen, 2005); (vii) dominance of the “linear model” of innovation policy approaches (and of related economists as consultants) (Edler, Kuhlmann & Smits, 2003:5); (viii) whether the attainment of a green economy constrains other objectives such as growth, poverty eradication, job creation (Khor, 2011:15-22); (viii) how to identify and deal with trade-offs (Khor, 2011:15-22). Epistemological challenges result as the consequences of risks can only be partially known and many ‘solutions’ remain open-ended, and fallible, as scientific certainty remains elusive (Lotz-Sisitka & Lupele, 2006:49); and (ix) Competition and personal ambition, in policy systems arise not only from structural factors, but also stem from individual policy makers' ambition, competition for status and scarce resources, which can lead to rivalry, turf and loss of coherence. Specific policies may be defined in ways that define others as rivals (OECD, 2005c: 11).

The concept of (sustainable) development has been criticised in discourse analysis in the sense of ‘unmasking’ development as ‘myth’ or ‘fairy tale’ (Pieterse, 2010:14) that is, development is ‘only a story’, only a narrative, only a grand narrative. Pieterse (2010:15) further elaborates that in a methodological sense the ‘myth’ is a contradictory move: the very point of discourse analysis is that discourse matters, talk and representation matter; representation is a form of power, it constructs social realities. Prominent developmental challenges facing South Africa include the ageing of the research population, immigration flows, the financing of the social security system, prevention of infrastructure congestion and environmental degradation that require long-term vision and strategies. The aforementioned developmental problems are too enormous to be addressed from one sectoral perspective only. Similarly, the creation of separate, “departmentalisation” (Arnold & Boekholt, 2002:24) and relatively closed departmental research and innovation networks has a risk of preventing the South African government from receiving the highest quality and/or independent advice. Review of the 2008 TYIP indicates that the South African government faces a challenge of discovery an appropriate path for undertaking the transition from the resource-based to the knowledge economy, including interventions to address the two economies paradigm and create an improved focus on spatial development. Other SD challenges facing South Africa include: (i) required improvement of regional environment, implementation of NEPAD to facilitate high growth rates in SADC (ii) lack of a common and consensual national vision; (iii) policy implementation and integration issues; (iv) bias in government vision for social and economic development, without integrating environmental sustainability; (v) inadequate M&E of various plans and approaches; (vi) the need to strengthen capacity for sustainable local development (vii) how to successfully move towards a longer-term view in development planning; (viii) the need for improved interactions between government and society; and (ix) meeting basic human needs, while building the economy are (ECA, 2010a:35-36). To this end, the next section provides the chapter summary.

3.12 SUMMARY

This chapter has presented a literature review on the South African public administration and public policy, which has provided the NSI policy framework foundation for reviewing collective efforts among the NSI actors in an integrated and holistic manner. This was done through providing a discussion of South Africa's NSI policy development, making reference to existing policy framework such as the 1996 White Paper for S&T in South Africa. A summary of OECD South African NSI Country Review and the evolution of various SD innovation policy models were provided. A review of research, knowledge and policy challenges facing South Africa within the NSI were also undertaken.

The chapter has shown that the government is embarking on the NGP (EDD 2010), a long-term project that argues for concerted state intervention in the economy to construct a developmental state. However, the chapter has revealed that the current role played by the state in the NSI has failed to deliver the transformations in policy and system performance needed to realise the potential of the South African NSI to drive SD, namely: economic, social and environmental pillars. There is a mismatch between the intentions of the NGP, the TYIP and the Twelve Outcomes of government and their associated Delivery Agreements. In order to synergise the governance and orientation of the NSI with the objectives of the NGP, it is important to re-orientate the present shape and form of the NSI. The chapter found that governance of NSI encompasses prioritisation, agenda setting, the formulation of policies and regulations and implementation accountability. An essential feature of accountability is policy learning that rests upon monitoring, measurement and evaluation, for review and synoptic purposes. The chapter has further established that the ability to detect bottlenecks, inefficiencies and perverse behaviours arising in policy implementation, and to act thereon, are elements of sound governance systems pivotal in South Africa’s public policy and public administration. Next, the research examines the history, governance, present policies and institutional structure of the NSI.

CHAPTER FOUR

KEY FEATURES AND PERFORMANCE OF NATIONAL INNOVATION SYSTEM

4. NATIONAL INNOVATION SYSTEM

Chapter Three has provided a literature review on the construct of public administration and public policy in South Africa. This chapter examines the history, governance, present policies and institutional structure of the NSI.

4.1 INTRODUCTION

The literature review provides a landscape of the NSI that will be utilised during the data analysis and in framework construction. An assessment of South African NSI performance reveals the pattern of both strengths and weaknesses and provides some pointers on the future landscape and trends. A general overview of literature indicates that South Africa requires strongly linked domestic and international NSI framework conditions. Literature on the NSI framework and theory provides this research with a useful a platform for examining SD through research for innovation. The aforementioned observation has been made through the exploration of the components and key issues in the South African NSI literature.

This research utilises various approaches, which include *ex post* and *ex ante* examination of the South African NSI. The chapter is organised as follows: section 4.2 is a discussion of the NSI theoretical framework in terms of the mechanisms and provides a general overview of the system. Section 4.3 reviews the terms that make up the construct of NSI, namely: national, system and innovation. Section 4.4 presents a discussion on the historical perspectives of the South African NSI, while section 4.5 is a review of the structural transformation of the South African NSI. Section 4.6 outlines the structure of the South African government NSI, which operates at four levels. Section 4.7 is a review of the two main components of the innovation system identified in the literature, which are education and research (or knowledge infrastructure), on the one hand, and the political system (or policy and governance), on the other. Most importantly, this section examines the provision of an enabling environment for innovation in the private sector and social spheres, through appropriate policy and regulations and the promotion of knowledge transfer and exchange. The section further explores the means for strengthening of human capital development (HCD) among other NSI components. The section identifies that knowledge infrastructure, policy learning, M&E and funding should be utilised as key levers for steering the NSI. The section also reviews South Africa's current and evolution of innovation indicators for SD through research in the NSI. Section 4.8 makes use of a tripartite model that reviews literature on the structure of the three main actors and responsiveness of the South African NSI. Section 4.9 presents a discussion on the strengths and weaknesses of the South African NSI. Section 4.10 is the chapter summary. Having briefly introduced this chapter, the next section reviews the NSI theoretical framework mainly from a South African perspective.

4.2 NATIONAL SYSTEM INNOVATION THEORETICAL FRAMEWORK

Table 4-2-1 provides a summary of definition of concepts related to the NSI, which include key terms such as "innovations", "innovation policy", "organisations" and "institutions" among others.

Table 4.2-1: Definitions of NSI Key Terms

INNOVATION CONCEPT	BRIEF DEFINITION OF THE CONCEPT
Innovations	New creations of economic significance primarily carried out by firms (but not in isolation), which include product innovations as well as process innovations.
Product Innovations	New – or improved – material goods as well as new intangible services; it is a matter of what is produced.
Process Innovations	New ways of producing goods and services - may be technological or organisational; it is a matter of how things are produced.
Creation vs. diffusion of innovations	The dichotomy is partly based on a distinction between innovations that are 'new to the market' (brand new or globally new) and innovations that are 'new to the firm' (being adopted by or diffused to additional firms, countries or regions). In other words, 'new to the firm' innovations is actually (mainly) a measure of the diffusion of innovations.
Systems of innovation (SIs)	Determinants of innovation processes – that is all important economic, social, political, organisational, institutional and other factors that influence the development and diffusion of innovations.
Components of SIs	Include both organisations and institutions.
Constituents of SIs	Include both components of SIs and relations among the components.
Main function of SIs	To pursue innovation processes – that is to develop and diffuse innovations.
Activities in SIs	Factors that influence the development and diffusion of innovations. The activities in SIs are the same as the determinants of the main function. The same activity (for example R&D) can be performed by several categories of organisations (universities, public research organisations, firms).
Organisations	Formal structures that are consciously created and have an explicit purpose. Organisations are players or actors.
Institutions	Sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organisations. Institutions are the rules of the game.
Innovation policy	Actions by public organisations that influence the development of innovations.

Source: Edquist (2008:27)

As indicated in Table 4.2-1, innovations are creations of economic and societal significance. Similar to Edquist (2008:16) Table 4.2-1 also implies that 'innovation' is certainly a wider concept than 'technology', implying that in twenty-first century, scope and emphasis of 'policy' changed from a focus on 'industrial policy' in the 1970s to 'technology policy' in the 1990s and the current much wider 'innovation policy'. Industrial policy is a nation's official total effort to influence sectorial development and, thus, the national industrial portfolio (Bingham, 1998:6). This research views market failure, which has often been cited by, for example, OECD (2005c:11) and Bingham (2006:294) as a reason for national policies to correct negative externalities and/or to promote the national interest. This research broadly explores two theories and models of innovation, namely: the innovation systems (Freeman, 1987; 1995; Nelson, 1987; 1993), and triple helix (Leydesdorff & Etzkowitz, 1996; Leydesdorff & Meyer, 2006; Etzkowitz, Dzisah, Ranga & Zhou, 2007), both of which have become integral parts of innovation policies. The theory of NSI and that of the triple helix share kinship with economic theory, such as evolutionary economics and theories of competitiveness as shown in Table 4.2-2.

Table 4.2-2: The theories of innovation-producing arrangements in brief

	INNOVATION SYSTEMS	TRIPLE HELIX
Innovation: what?	Co-development, diffusion and use of innovations, particularly new technologies	Re-combinations: governments affect innovation dynamics by changing laws /regulations, creating new markets and funding organisations
Innovation: how?	Systemic and evolutionary interaction between organisations and institutions	Evolutionary and dynamic interaction in a complex network system of university, industry and government relations

Source: Leydesdorff and Etzkowitz (1996:12)

The two theoretical approaches shown in Table 4.2-2 are joined together by the view that innovations are produced through the triple helix arrangement and interaction of the actors. In this research context, the use of theories has provided a deeper appreciation of the agenda-setting role played by the theories in the form of a set of policies with implications. The use of theories also adds into the awareness of the multiple layers of the concept of innovation and related theories in terms of the shifting relations among the following iterative cycle of practical research translating into policy, then into an ideology then into theory (Schwabe, 2002:12; Pieterse, 2010:8). The next section reviews the terms that make up the construct of NSI, namely: national, system and innovation, each of which is of importance for the South African NSI framework conditions.

4.3 THE CONSTRUCT OF NATIONAL SYSTEM INNOVATION

Identifying the scholar who first coined the term 'innovation system' has been a dilemma in academic literature, with some of the basic ideas behind the concept of NSI going back to List (1841/1959) who developed the construct as the basis for a German 'catching- up' strategy. List's (1841/1959) concept of 'national systems of production' took into account a wide set of interactions among national institutions including those engaged in education and training as well as infrastructures such as networks for transportation of people and commodities (Freeman, 1995; Edquist et al., 2009:11). At the end of the 1980s, economic innovation research increasingly began to concentrate on the co-development of firms and technologies, viewing innovation as not static, but rather as taking place in evolutionary systems, the so-called innovation systems (Carlsson & Jacobsson, 2002). The NSI approach was developed through a decade of academic research and policy analysis to provide a framework and quantitative information for assessing whether and how the contribution of public policy to national innovation performance can be improved (Foray, 2010:92). According to Viotti (2002:670), in the evolutionary approach, changes in the components of the system lead to the emergence of new interactions, heterogeneity and innovation processes for supporting knowledge commercialisation. While the modern version of the concept of NSI was developed mainly in rich countries, some of the most important elements going into the combined concept came from the development issues and literature of third world countries (Johnson, Edquis &, Lundvall, 2003:2-3). In applying the system theory, the International Organisation for Standards ISO/DIS 31000 (2009) ISO clause 7.1 states:

> For organisations to function, they have to define and manage numerous inter-linked processes. Often the output from one process will directly be converted into the input into the next process. The systematic identification and management of the various processes employed within an organisation, and particularly the interactions between such processes, may be referred to as the "process approach" to management.

The pioneering in writing of the concept of innovation systems can be attributed to scholars such as Rosenburg (1982), Freeman (1987) and Edquist (2005), among others. In order to provide context to his own work Lundvall (1992) reviewed the literature of List (1841/1959), Freeman, (1987), Nelson (1987:1993) and Porter (1990). By so doing, Lundvall (1992) and his colleagues such as Edquist et al. (2009) have been able to move towards the relevance of innovation and interactive learning. At present, the most developed influential innovation approach and definition in research is one that emerged in the mid-1980s, namely: the concept of NSI defined by Freeman (1987). In the proposed NSI approach, Freeman (1987) used the construct of NSI to articulate the important role of the state in developing a country's technological infrastructure. Freeman (1987:1) defines NSI as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". NSI places technology and innovation at the centre stage of development and pays particular attention to the history and institutions that shape the interactions of the NSI actors. According to the OECD (2005c), the NSI is intended to promote innovation, encourage synergy between the various sectors, institutional and infrastructural elements and develop a research framework in line with national priorities.

According to this research scope, the South African NSI is viewed as consisting of six main actors: (i) industry (both privately and publicly owned) (ii) institutions of higher education (iii) science councils (both performing and agency) (iv) government departmental research institutes (v) museums and other statutory bodies and (vi) non-governmental organisations, which play the role of funders and performers in the system. All the NSI institutions are embedded within the financial system of innovation, the country's legal framework and national politics that includes learned societies, associations, trade organisations and other civil society organisations. There is reason to emphasise the importance of a favourable business environment that provides strong incentives for innovative activities (Kokko, 2010:126). Oyelaran-Oyeyinka and McCormick (2007:23) note that adopting a systemic approach that supports the development of the local and NSI within which S&T and innovation should be embedded in good practice.

The NSI constitutes a multitude of porous sub-systems that are geographically dispersed, sectoral or institutional in nature, each of which may be promoted or hindered its own right, directly or indirectly. Apart from being permeable, openness is an important and fundamental feature of the NSI required in the enabling environment for innovation (Marcelle, 2011:5). This research recognises a variety of mental models that work to shape the way that NSI network participants engage within the system. The concept of the NSI has, nevertheless, proved to be open to widely divergent interpretations. However, the SA DST Ministerial Review Committee (2012:86) states that "the various actors have brought their distinctive interests to bear on how they relate to the idea, if they relate to it at all". Within this research, the use of mental models facilitates the determination and interpretation of the construct of NSI. Furthermore, in this research the NSI concept is used as a powerful metaphor for describing the many South African NSI policies and network interactions. Edquist (2005:182) provides a broad definition of NSI as:

> All important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion and use of innovations… a system consist of two kinds of entities: there are firstly, some kinds of components and secondly, there are relations between these.

The apt definition of NSI adopted in this research defines the NSI as the:

> Set of functioning institutions, organisations and policies which interact constructively in the pursuit of a common set of social and economic goals and objectives, and which use the introduction of innovations as the key promoter of change (Department of S&T 2002:22; Paterson, Adam & Mullin, 2003:6).

Using Freeman's (2002:194) terminology in this research, the "broad" approach is utilised to recognise that the "narrow" institutions are embedded in a much wider socio-economic system in which political and cultural influences as well as economic policies assist in determining the scale, direction and relative success of all innovative activities. In other words, the broad and narrow definitions enable the research to converge the differing territories and strongly divergent fields of the NSI practice. The broad and narrow definitions reveal several crucial elements of the NSI, namely: (i) a set of institutions; (ii) involves a set of social and economic objectives; (iii) entails framework conditions; (iv) policies implementations are crucial; (v) involves interacting network of institutions; (vi) is evolutionary in nature.

Figure 4.3-1 attempts to illustrate both narrow and the broad perspectives of the NSI construct. The narrow definition is a subset of the broad perspective, which includes different, connecting sub-systems that are influenced by various contexts such as historical processes, geopolitical, institutional, macroeconomic, social, and cultural.

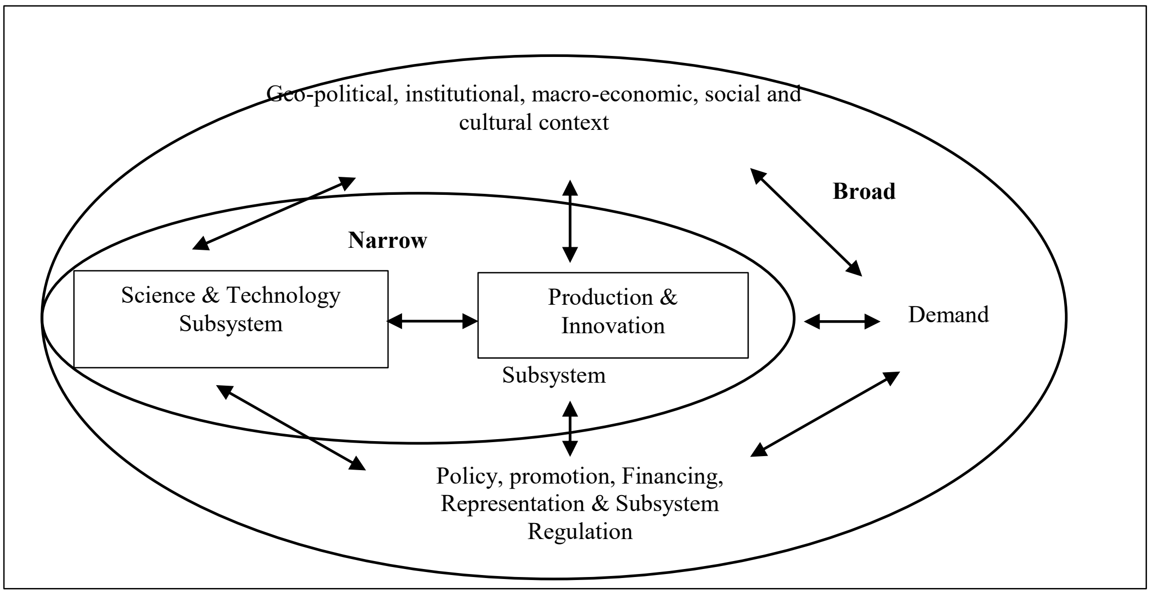


Figure 4.3-1: Narrow versus broad perspective of the NSI
Source: Cassiolato and Lastres (2008:11); Cassiolato and Soares (2014:xxx)

Although some literature has tended to focus on the elements illustrated in Figure 4.3-1 of the NSI in a narrow sense with an emphasis on R&D efforts and S&T organisations, the broader perspective of the NSI offers an extensive scope for this research. This research unbundles the terms that make up the concept of the NSI, namely: (i) national; (ii) system and; (iii) innovation, each of which is of importance for the South African NSI framework conditions as follows.

4.3.1 National Networks

Reviewing literature on the NSI linkages is fundamental to the functioning of the dynamics of the South African system. Lost connections present a challenge to NSI actors, specifically the South African government. This research views the restoration of lost connections or the establishment of new connections as an important asset for SD through research in the NSI. The argument is that managing the NSI actors' perceptions and expectations during policy making is vital because dissatisfied or disillusioned stakeholders can cause policy failure.

The term 'national' from this research standpoint, refers to the South African government's mechanisms that provide a framework for policies to take effect and for measures to be devised that reflect objectives of the government for innovation to achieve transformative effects across the economy for SD. From this research perspective, the national view is important for achieving a coherent and overall strategic perspective for planning, analysis, M&E of policies. This research further attributes the skewed, unequal patterns of development in which innovation has flourished in traditionally strong sectors of the economy to failure in government to view innovation systems as constituting a multitude of intertwined sub-systems. Abrahams and Pogue (2010:23) note that rather than ameliorating the NSI, the historical precedent has inadvertently resulted in deepening inequalities and imbalances.

This study endorses the definition of "networks of innovators" by the IDRC (1993:11), which refer to both formal and informal NSI network arrangements. The term 'network' refers to patterns of interactions between society and state, and within the public sector itself (Olsen, 1987:6; Kickert, 1995:9; Peters, 2006:124; Oyelaran-Oyeyinka & McCormick, 2007:17). Examining the NSI networks provides this research with a mechanism to conceptualise the complex relationships among the societal elements (Heclo, 1978; Rhodes, 1997; Deleon & Martell, 2006:41). Foray (2010:106) states that the "network can be created by way of institutionally grounded empirical inquiries, towards a fundamental reorientation of policies to encourage the local adaptation and distribution of knowledge to potential clients". In this context, the South African government is a legitimate unit of analysis for the NSI as functioning and interaction of a plethora of actors for commercialisation of research. This research portrays entities such as enterprises, scientific institutions, governments, agencies and research institutes as connected networks nodes.

In many ways, the networks theory provides an appropriate unit of investigating the South African NSI, because contemporary policy issues are attended by social actors, hopefully but not always cooperatively (Deleon & Martell, 2006:40-41). The local seedbeds or 'millieux of innovation' (Koppenjan & Klijn, 2004; Bekkers et al., 2011a:7) are shaped, mediated and channelled by institutional arrangements (Powell, 1998:2). In much policy discourse, invocation of the power of networks is essentially a mantra, which is more than a 'network' metaphor into a legitimately well worked out NSI model Apart from the recognised NSI actors in this research scope, the South African citizen plays an important role in the NSI network (Leydesdorff & Etzkowitz, 1996). From the economic theory perspective proposed by scholars such as Schumpeter (1934), Lal and Keen (2005), Rodrik (2007) and Bell (2007), in this research context a competitive economy citizens create the demand for goods and services.

4.3.2 Systems

The system approach has been considered ideal for examining the activities and outcomes leading to economic and social impacts of the NSI actors. As such, the system approach is used to imply classifying the components of the NSI and the resulting consequences of SD in South Africa through research.

Webster's Collegiate Dictionary (2011) defines a system as "a set or arrangement of things so related or connected as to form a unity or organic whole". Systems, according to Carlsson and Jacobsson (2002:235), are made up of components, relationships and attributes. Scholars such as Bernal (1967) and Goffin and Mitchell (2009:19) view a system as being greater than its parts. From a 'system' perspective, innovation is regarded as "an intricate interplay between micro and macro phenomena. In this case macro-structures influence micro-dynamic and new macro-structures are shaped by micro-processes (Lundvall, 2007:101). Complex systems such as the NSI are dynamic and often display non-linear properties (Bernal, 1967). Traditional theories have depended on closed systems approach, thereby disregarding the differing environments and the nature of dependency on environment (Robbins, 1987:11; Katz & Kahn, 1996: 29), such as those of the NSI actors. This research recognises that open, unlike closed systems, are dynamic and fluid allowing interaction with the environment. Similar to Hillman et al., (2011, 406), in the system performance entails the combined result of all the key processes, the structural elements, and the feedback loops between those creating dynamics. This research further views the systemic character of South Africa's NSI as that which reflects the plethora of NSI actors in order to realise shared objectives.

4.3.3 Innovation

The concept of innovation is explored in depth in a later section of this chapter. In brief, this research views innovation as the process of commercialising research for SD. Bhatta (2003) and OECD (2003:11) define innovation as the process of converting new or existing knowledge to value for the benefits of individuals, groups or communities. This research shares similar views with Varis and Pellikka (2004) that innovation does not occur in isolation but within a complex, interactive and interdependent network of multiple actors and influences, and within dynamic systems. Accordingly, innovation takes place through knowledge conversion to value, which is shaped by various complex interrelated factors such as political, social, cultural, structural, institutional and organisational. Having explored the construct of the NSI, the next section is literature review on the NSI historical perspective and arrangement.

4.4 HISTORICAL PERSPECTIVE OF SOUTH THE AFRICAN NATIONAL SYSTEM INNOVATION

This section explores literature on South African NSI the historical development. South Africa's NSI most outstanding achievement has entailed transcending the difficulties created by the poor framework conditions of the early 1990s.

South Africa's NSI can be traced to mining, agriculture and health led by research organisations such as Elsenburg (founded in 1898) and Onderstepoort (1908), the South African Institute for Medical Research (SAIMR) (1913), the South African Sugarcane Experiment Station (1925) and The Council for Mineral Technology, Mintek (1934). According to IDRC (1993:41), MINTEK has an "agency role" and spends about 2% of its budget (almost R1.6-million as at 2012) on financing HEIs research. The South African mining-led industrial revolution triggered the rise of the mining oligopolies (Innes, 1984) and arguably 'Developmental State I' that set out to secure the interests of the then power-holding minority, which rested on state enterprises (energy, communications, iron and steel, irrigation schemes), later adding a military-industrial complex (Kahn, 2011).

The 'Developmental State I' combined free market principles with high degrees of regulation and administered prices. One of the first shifts of the Developmental State I took place with the 1979 privatisation of Sasol. This was followed by the corporatisation of South African Railways and Harbours and Eskom, the 1989 privatisation of ISCOR followed by deregulation of agriculture. The end of Developmental State I was foreshadowed by the 1970s, rising worker militancy, the collapse of the Portuguese dictatorship in Mozambique, the Soweto Revolt, the cost of the Bantustans, runaway arms expenditures, the oil crises, and the overthrow of Shah Pahlavi's Iran.

Adjustment continued to take place in the private sector with the shrinking of military procurement (SA DST Ministerial Review Committee, 2012:104). The new realities of globalisation resulted in some of South Africa's private enterprises, market leaders generating about one half of the enterprise revenues abroad, resulting in three South African economies, not two, namely: (i) a rich domestic economy; (ii) a poor informal economy; and (iii) a rich offshore economy (Kahn, 2011:6-9; SA DST Ministerial Review Committee, 2012:104).

In 1945 the CSIR spin-out to include the Atomic Energy Board, HSRC, MRC, Water Research Commission (WRC) as well as the National Research Institute for Oceanology. The CSIR also established industry research associations for leather, paint, fish-processing and sugar milling with funding from industry levies and the state. Other research institutes to follow included (i) a 'securocratic' system of innovation next to the Plant Protection Research Institute, (ii) the Onderstepoort Veterinary Institute, (iii) and the police forensic laboratories in Pretoria, and (iv) the Institute of Maritime Technology and various companies active in radar technology. Other sectoral systems of innovation functioned in energy, grain, viticulture, forestry, pulp and paper, and material. The South African market leaders were, and remain, actors in those sectoral systems, which include Sasol, SAB Miller, Distell, Sappi and Barloworld. With the addition of the South African Bureau of Standards (1945), HSRC (1968), MRC (1969), Agricultural Research Council (ARC) (1990), Foundation for Research Development (FRO) (1990), and Council for Geoscience (1992) in conjunction with the universities, the then technikons, technical colleges, industry training centres, and private research laboratories, the South African NSI begun to take shape.

Globally, including the South African context, historically the science councils followed the Bush principle: "give us the money; we shall give you the results" (SA DST Ministerial Review Committee, 2012:117). Across the world, PRIs have continued to operate under a range of income models, from being wholly-funded by government grant to almost entirely being funded by contract research or project. Even so, trading with the market was encouraged and, on average, the CSIR earned 40% of its income from contract research from the late 1960s onwards (Walwyn & Scholes, 2006:241). However, the DACST (1996:18) notes that the Developmental State I of the pre-1994, being sectional biased, failed to address the 1996 White Paper of the NSI. Therefore, this research reviews the current structural transformation of the South African NSI. To this end, the next section reviews the structural transformation of the South African NSI.

4.5 STRUCTURAL TRANSFORMATION OF NATIONAL SYSTEM INNOVATION

Major influences on the shape of the South African NSI from 1994 have stemmed from policy changes, particularly in the combination of economic liberalisation and radical reductions in large areas of public support for R&D and technology-intensive production.

In April 1988, the South African government adoption of a system of "framework autonomy" as the basis for the management of the statutory councils was a significant step, which terminated a system of excessive micromanagement of the seven research institutions. The South African Green Paper of January 1996 and represented the first major policy consultation, developed explicitly using the NSI approach. However, the adoption as policy of the DACST/DST White Paper on S&T in 1996 signified the beginning of the NSI approach. The formal approach progressed to the more focused 2002 NSRD, which sought to re-orient the NSI system. During the last decade, the formal approach has moved to the more narrowly defined strategies for specific areas of technology such as the National Biotechnology Strategy in conjunction with a range of policy frameworks that directly influence the development of the NSI, such as Advanced Manufacturing Technology Strategy.

The scrapping of the Science Vote in 2005 resulted in the science research councils becoming even more autonomous of the DST. The single Science Vote is the result of the Rothschild (1971) principle of separating customers and contractors in the UK to allocate portions of the money to the respective customer ministries, which criticised the high level of self-determination by the research community in relation to government-funded applied research:

> This is wrong. However distinguished, intelligent and practical scientists may be, they cannot be so well qualified to decide what the needs of the nation are, and their priorities, as those responsible for ensuring that those needs are met. This is why applied R&D must have a customer (Rothschild Report, 1971; cited in OECD, 2007c:227).

In the NSI, the South African DST is essentially a policy department, which oversees payments transfer to the statutory bodies for which it has responsibility, while major responsibility for grant-making is the role of the National Research Foundation (NRF), WRC and MRC. The CSIR was transferred from the DTI to the DST, and the HSRC lost its agency function to the new NRF. Critics for example OECD (2007b) and SA DST Ministerial Review Committee (2012) of the DST maintain that the concept of NSI has failed to gain adherents beyond the DST. This government failure has resulted in the lack of traction, such as: (i) unfavourable position of the Ministry of S&T in the hierarchy of government departments; (ii) lack of appreciation of the long-term value of S&T; (iii) the persistence of the research-led linear model of innovation; and (iii) trade union hostility to the 'creative destruction' of new technologies (OECD, 2007b; SA DST Ministerial Review Committee, 2012).

Despite the shortcomings of the NSI, notable pioneering initiatives and positive achievements of the DST include; (i) South Africa's ability to effect large projects such as the Southern African Large Telescope (SALT) and MeerKAT, and the world class bid to host the Square Kilometre Array (SKA); (ii) introduction of Centres of Competence, established to drive efforts to develop industry-relevant products for commercialisation; (iii) the South African Research Chairs Initiative (SARChl), the university Centres of Excellence and Centres of Competence, the achievements in genomics and early humanoid research and South Africa's participation in many international scientific projects; (iv) the launch of the IF and BRIC; (v) the setting up of National Centres of (Research) Excellence and, more recently; (vi) aggregating and further evolving major components of the National Space Programme; (vii) significant public policy initiatives within the NSI, which were first flagged in the 2002 NRDS have been established since the OECD 2007b Country Review. The initiatives include the establishment by statute of the Technology Innovation Agency (TIA), the passage of the IPR from Publicly Financed Research law (Act No. 51 of 2008) and the establishment of the associated National Intellectual Property Management Office (NIPMO), in alignment with an evolving industrial policy framework and university technology transfer offices, and support towards the costs of patenting; (viii) the operation of a spectrum of schemes to enhance R&D cooperation between business and HEIs; (ix) fostering the growth of the Academy of Science of South Africa (ASSAf); (x) on-going interventions in the technical and knowledge-using capacitation of small and medium enterprises (SMEs) (through technology stations).

However, balanced against the notable accomplishments are the reservations expressed by the OECD (2007b) South African NSI Review, which is largely congruent with the SA DST Ministerial Review Committee (2012) assessments. Notable assessments include the lack a shared comprehension and purposes across South African government departments. The implementation of the NSMM organisational model in 2004 has resulted in the inability of the DST to establish a truly systemic, coordinated and coherent policy framework for promoting NSI in South Africa. Most of the prospective NSI planning, as envisaged in the 1996 White Paper, has not been implemented.

The NACI has been constrained to 'advise' only in the same limited NSI domains in which the DST can operate. The reliance on the linear model of innovation, the supply-side thinking remains pervasive in South Africa's NSI, which has resulted in a poor market response and social demand. The network relationship between the private sector, the government, HEIs and civil society is weak, unsystematic, lacks coherence and lacks common purpose. This weak relationship has a ripple effect on the South African NSI functioning, including governance, resource allocation and decision-making and in the agenda for national (sustainable) development.

The IDRC 1993 Mission Report examined the S&T system and concluded that the system displayed a leadership vacuum, promoted sectional interests, was underfunded, poorly coordinated and needed "to demonstrate that it can apply its technical skills to the real developmental needs of the majority" (IDRC, 1993:23). The 1993 Mission Report further established that there were no articulated economic or social goals and objectives that could have been applied by the various South African institutions. The vacuum resulted in freezing of resource allocation. The Mission Report found that there was an immediate need to transform the highest levels of governance of the S&T institution (IDRC, 1993:23-24). The aforementioned challenges are still facing South Africa's NSI in the 21st century.

The OECD (2006:11) acknowledged that extensive transformation has been undertaken in the South African NSI since 1994. The transformation includes the rationalisation of structures and actors within system and the realignment of the systems' priorities to address South Africa's SD imperatives. Closer alignment of policies with international trends, including strengthening linkages within the system and with the system of other countries has also taken place. Transformation of human resources base has taken place in order to reflect the country's demographic profile as well as the re-allocation of resources to ensure greater participation and inclusion of all institutions, especially previously disadvantaged institutions (OECD, 2006:11). This research now turns to the literature review on structure of South Africa's NSI.

4.6 STRUCTURE OF NATIONAL SYSTEM INNOVATION IN SOUTH AFRICA

Generally, the structure of the South African government NSI operates at four levels (OECD, 2007b:22; SA DST Ministerial Review Committee, 2012:16) as illustrated in Figure 4.6-1: (i) high-level institutions stature mandated to provide policy advice to government on innovation, or innovation-related functions including the NACI, the Council on Higher Education (CHE) and the National S&T Forum (NSTF); (ii) government ministries and departments; (iii) research and innovation agencies, including the NRF and the MRC; and (iv) research-performers, including universities and science council, along with providers of scientific and technical services.

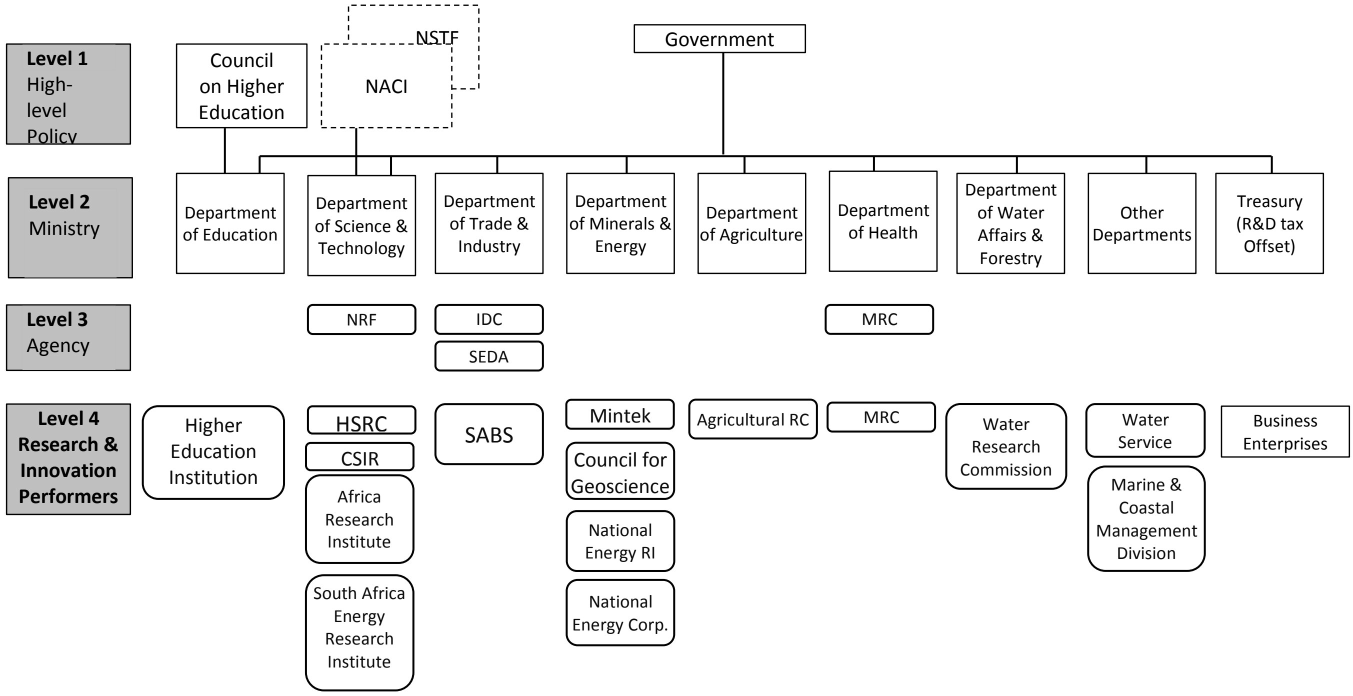


Figure 4.6-1: Institutional structure of the government research and innovation funding system
Source: OECD (2007:107)

There is no high-level body responsible for deciding or advising the South African government as a whole, about the entire spectrum of research and innovation policy. As shown in Figure 4.6-1 at the highest Level 1, the Parliamentary Portfolio Committee for S&T (comprising members of Parliament) oversees the activities of the DST. Level 1 involves setting overall directions and priorities across the whole national innovation system (OECD, 2008:164). The Minister of Education is advised by a group of stakeholders in the CHE, the main statutory advisory body according to the SA DoE (1997:2.12), White Paper 3. The Minister of S&T is advised both by the NACI and the larger group of stakeholders involved with the NSTF.

Levels 2 and 3 consist of research councils, which are widespread and pursue independent policies. Levels 2 and 3 co-ordination may involve administrative aspects, policy issues or both and receive a substantial grant from the responsible ministry. For example, the MRC has a mixed function of setting internal priorities and performing research, on the one hand, and acting as a funding agency for external contractors (primarily in the higher education system), on the other. Level 4 involves co-ordination among the bodies that actually perform research and innovation, which tends to be achieved through self-organisation, rather than formal mechanisms (OECD, 2007b:223). The South African NSI shows no formal horizontal co-ordination mechanisms in place at Levels 3 or 4, which results in an unbalanced mix of instruments, gaps and mismatches in terms of resource availability (OECD, 2007b:223). Most of the research-performing institutions are formally controlled by the parent ministries. The universities, however, have their own charters and are not instructed directly by the Ministry of Education.

At horizontal co-ordination at Level 2 the South African ministries organise a number of policy clusters that deal with problems and responsibilities, such as the economics I cluster, economics II cluster and the social 2 cluster. The OECD (2007b:109-110) and SA DST Ministerial Review Committee (2012:16) established that the clusters approach are inefficient in terms of providing the NSI co-ordination mechanisms. The DST also has a number of special responsibilities for horizontal co-ordination in managing specific institutions (OECD, 2007b:109). The DST also performs system-wide oversight functions, which include establishing and maintaining a common governance framework, priority setting and performance and budgetary monitoring systems (OECD, 2007b:110).

At horizontal level, the DTIs responsibilities include aspects of technology-related innovation and entrepreneurship, often on a shared basis with DST. The DTI also incubates a small number of firms in the biological and life sciences, medical devices, bio-diesel, essential oils, chemicals, construction, floriculture, furniture, ICT, small scale mining, stainless steel, aluminium, platinum and metal beneficiation sectors through the SEDA Technology Programme.

The next section is a review of the two main components of the innovation system identified in literature, which are education and research (or knowledge infrastructure) on the one hand, and the political system (or policy and governance) on the other.

4.7 COMPONENTS OF NATIONAL SYSTEM OF INNOVATION AND THEORIES

This section reviews literature on the identified components of the NSI and related theories within the South African NSI. The components can be classified into two pillars of government that comprise and enable the entire functioning of the NSI, namely: the DST and Department of Higher Education and Training (DHET), on the one hand, and the DTI, on the other. Network interaction should exist between the two pillars for the South African NSI functioning.

The South African NSI consists of five intersecting national sectors, (each comprising a set of institutions with a common objective, and four interdependent functions illustrated in Figure 4.7-1. The functions are explored in this research.

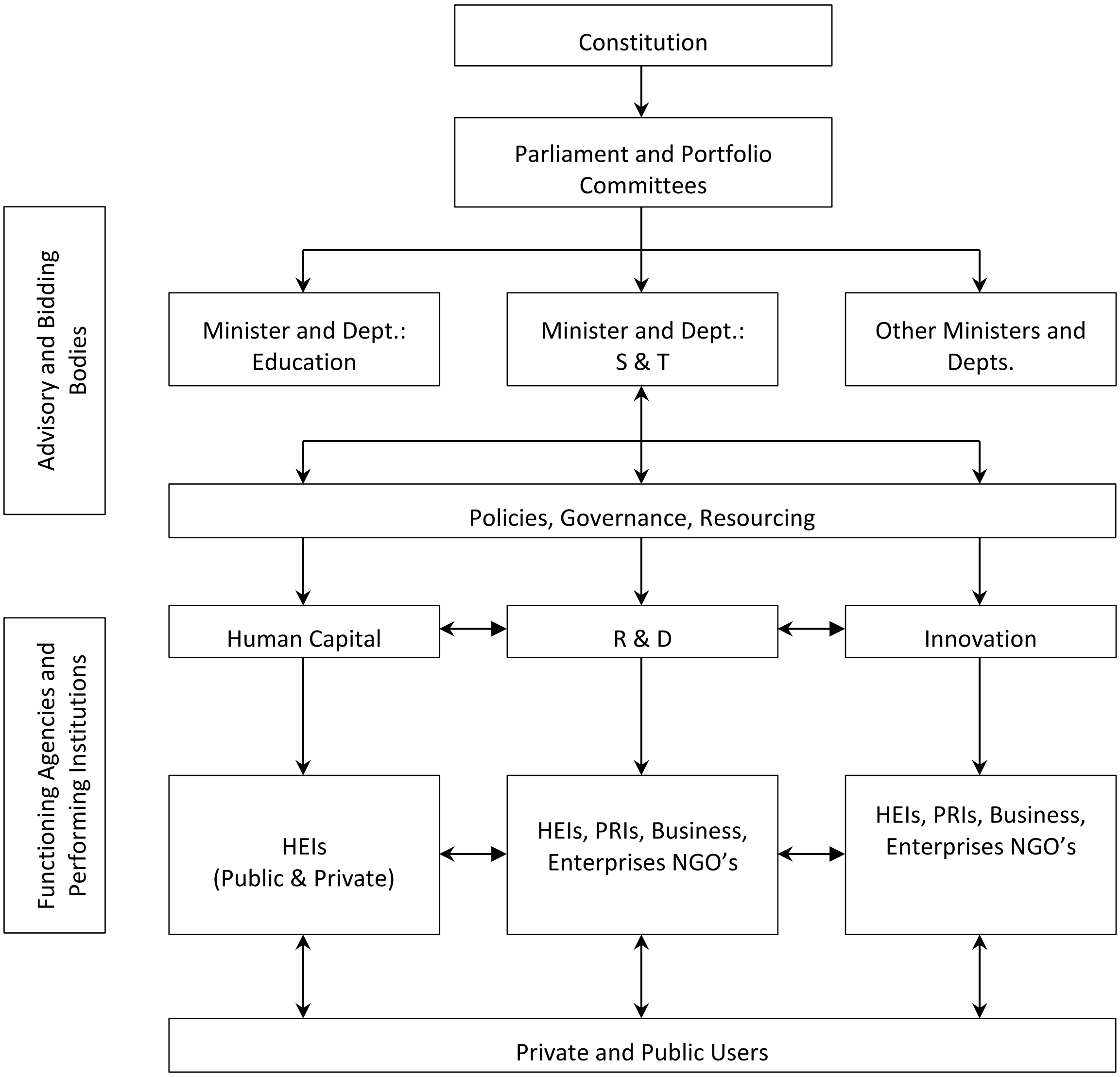


Figure 4.7-1: Overall structure of the NSI
Source: OECD (2006:21)

The 1996 White Paper provides a number of yardsticks for assessing the performance of the system and argues that a well-functioning NSI would have the following features:

Government should have ensured that:

I. South Africa has in place a set of institutions, organisations and policies that give effect to the various functions of a national system of Innovation.
II. There is a constructive set of interactions among those institutions, organisations and policies.
III. There is in place an agreed upon set of goals and objectives that are consonant with an articulated vision of the future which is being sought.

This would be achieved through government addressing:

IV. Policy formulation and resource allocation at the national level, and
V. Regulatory policy-making.

A second set of mandates is shared among government, business and higher education, comprising:

VI. Performance-level financing of innovation-related activities.
VII. Performance of innovation-related activities.
VIII. Human resource development and capacity building, and
IX. Provision of infrastructure.

To these should be added two other aspects that are covered in the White Paper, namely:

X. Performance measurement and evaluation, and
XI. Knowledge transfer

In the interest of conciseness, the research distils the eleven yardsticks to six attributes or components of the NSI as follows:

4.7.1 The NSI Framework Conditions (Items I, II, III & V)

The NSI Framework Conditions (items i, ii, iv, v & vi) include two broad categories. The first is the NSI the financial practices (national pattern of funding). The second is the regulatory systems established by government that operate within and across key NSI actors. The existence of favourable framework conditions is a major factor in enabling and facilitating SD through research in the NSI. Typically, the literature shows that SD and environmental policies have few resources for action, while S&T policies control the state budget for R&D allocations.

The overall purpose of the NSI framework is to pursue innovation processes, that is, developing and diffusing innovation (Edquist et al., 2009:13-14). Table 4.7.1-1 outlines ten key activities that take place in the NSI, which are the determinants of the development and diffusion of innovations, those factors that influence innovation processes (Edquist et al., 2009:13-14).

Table 4.7.1-1: Key activities found in systems of innovation

KEY ACTIVITIES IN SYSTEMS OF INNOVATION
I. Provision of knowledge inputs to the innovation process
1. Provision of R&D and, thus, creation of new knowledge, primarily in engineering, medicine and natural sciences.
2. Competence building, for example through individual learning (educating and training the labour force for innovation and R&D activities) and organisational learning.
II. Demand-side activities
3. Formation of new product markets.
4. Articulation of quality requirements emanating from the demand side with regard to new products.
III. Provision of constituents of SIs
5. Creating and changing organisations needed for developing new fields of innovation. Examples include enhancing entrepreneurship to create new firms and intrapreneurship to diversify existing firms; and creating new research organisations, policy agencies among others
6. Networking through markets and other mechanisms, including inter-active learning among different organisations (potentially) involved in the innovation processes, which implies integrating new knowledge elements developed in different spheres of the SI and coming from outside with elements already available in the innovating firms.
7. Creating and changing institutions – for example, patent laws, tax laws, environment and safety regulations, R&D investment routines, cultural norms, etc. – that influence innovating organisations and innovation processes by providing incentives for and removing obstacles to innovation.
IV. Support services for innovating firms
8. Incubation activities such as providing access to facilities and administrative support for innovating efforts.
9. Financing of innovation processes and other activities that may facilitate commercialisation of knowledge and its adoption.
10. Provision of consultancy services relevant for innovation processes, for example, technology transfer, commercial information, and legal advice.

Source: Edquist (2006:188)

From a policy point of view, the list of activities in the checklist (Table 4.7.1-1) can be used to explain (low) performance: identifying the deficiencies in the system and for the design of innovation policy (Edquist et al., 2009:18). The South African government has taken a number of measures to establish institutions, governance systems, resourcing initiatives and general framework conditions intended to create a supportive environment for innovation to take place. The measures includes the White Paper on S&T (1996), the NRTF Study (1997-1999), the NRDS (2002) and the NSMM South Africa's S&T system (2004), which are accompanied by the policy on Governance Standards for SETIs and framework for the development of a NST Expenditure Plan. However, the difficult issues of selecting and setting priorities for resource allocation among different areas of STI activities has led to the spreading of available resources too thinly across projects, programmes and institutions.

The South African government is the major funder of research among the NSI actors (DST, 2011:14) through, for example, the DTI, which is a significant funder of technology and research, via other agents. The programmes contained within DTI's Innovation and Technology mission includes the THRIP, which operates the programme on the DTI's behalf and the Support Programme for Industrial Innovation (SPII). The National Technology Transfer Centre (recently transferred from CSRI to the Small Enterprise Development Agency –SEDA), while the National Fibre, Textile and Clothing Centre (NFTCC) and the Godisa Trust, co-funded by the European Union (now merged with SEDA) fall under the DTI's programme. A small collection of incubators and training centres and the Mpumalanga Stainless Initiative, which teaches basic business skills to groups of 16 entrepreneurs in stainless programme steel sheet fabrication, receives the DTI's funding. Other programmes that fall under the DTI include the Down Stream Aluminium Centre for Technology, which operates similarly in aluminium casting with funding from KwaZulu-Natal, the European Union and the Furntech, a Swedish-funded training centre for furniture-making and entrepreneurial skills and the Venture Fund.

In South Africa, resource allocation across large-scale national programmes, such as the 'big science' projects and 'big technology' initiatives at the level of the NRF and the DST (OECD, 2007b:212), have obscured other types of innovation critical for SD within the NSI. In order to achieve socially optimal R&D investment levels and evade market failure, governments should finance research activities at public research organisations (Allman, Edler, Georghiou & Miles, 2011).

South Africa is 13th in the world (2.6% of the total) for the registration of plant varieties, an achievement involving the private sector, universities and the ARC. Considerable attention is often given to the ratio of R&D to GDP as a key indicator of the development of a country's innovation system, and a target of 1% seems to hold a particular fascination for many middle-income countries, including South Africa (OECD, 2007b:154). The 1% target has remained elusive. However, South African publications are among the top 1% of internationally cited publications.

The level of GERD, at current prices, amounted to R20.955 billion during 2009/10, compared to R21.041 billion during 2008/09. In current rand value, GERD decreased by R86 million to R20.955 billion during 2009/10 in contrast to the steady growth seen in previous years. GERD as percentage of GDP stood at 0.87% in 2009/10, a decrease of 0.05 percentage points from 0.92% recorded in the 2008/09 survey. A decline of 9.7% in business sector R&D expenditure, a significant contributor to R&D investment, is the primary driver of the trend. Other sectors that reported negative growth in R&D expenditure were the government and not-for-profit sectors, decreasing by 6.4% and 21.4% respectively. The positive growth of 21.7% in higher education sector and of 10.2% in science councils sector appeared inadequate to offset the larger decreases in the aforementioned sectors. The sources of funding for R&D remained largely "own funding", and the proportion of foreign funding of R&D has, as in the previous reference year (2008/09), shown a small but steady increase (DST/HSRC, 2013:9).

The latest available National S&T Expenditure Report of 2007 by the DST, reported a total spend of over R12 billion, just under 2% of the national budget, of which the lion's share was spent by the departments of DST (29%), Health (20%), Public Enterprises (19%), Environmental Affairs (6%) and Minerals and Energy (6%). The 2007 DST report has not provided accurate and reliable reports needed for the full and appropriate analysis of policy-making in the public sector. For instance, the inclusion of large expenditures on health services is inappropriate, while the omission of critically important transfers to research performers in HEIs by the relevant department is an unacceptable shortcoming, notes the SA DST Ministerial Review Committee (2012:90).

The proportion of R&D performed in South Africa, which was foreign funded was 12.1% in 2009/10, an increase from 10.7% in 2007/08 and 11.4% in 2008/09 (DST/HSRC, 2013:27). The science councils and business enterprises consistently attracted foreign funding of over 10%. In 2009/10, both the 8.7% of higher education R&D expenditure and the 5.1% of government R&D expenditure were funded by foreign sources (DST/HSRC, 2013:27). It is prudent to suggest that the distribution of expenditure on R&D among the major science councils should be revised to match the new R&D council mandates and continuous functions and services.

The CIS 2009/10 survey data shows that the private sector/industry is the largest contributor to GERD in South Africa in terms of being a source of finance for, and performer of R&D, and a key strategic partner for government that engages in promoting R&D investment in South Africa (DST/HSRC, 2013:34). Most of business R&D expenditure in South Africa is performed by large enterprises, with the top 100 R&D business performers accounting for almost 80% of BERD (DST/HSRC, 2013:34).

A study conducted by Botha and Von Gruenewaldt (2006) concluded that the public research system was seriously under-capitalised and inputs of around R700 million would be needed annually over six to seven years for its renewal compared to the present level of around R350 million a year. The autonomy enjoyed by university councils and executive management under the Higher Education Act (Act No. 101 of 1997) means that the ways in which the complex and highly interdependent functions of teaching, research and extension/outreach are set up and sustained are generally at the discretion of the HEIs.

The DHET, created in 2009, handles both schools and the higher education sector, which according to the OECD (2007b:128), "has introduced a new funding formula for universities which provides some (weak) incentives to encourage good research performance". In the NSI context, the OECD (2007b:24) states that "the formula underpinning the DoE funding stream should be reassessed with a view to providing stronger incentives for, and greater selectivity in resource allocation to, work of high quality", while arguing that measures for "ring-fenced funding are needed to foster the emergence of newcomers to the competition" (OECD, 2007b:24).

4.7.2 NSI Human Resources and Human Capital Development (Items VI & Viii)

This sub-section reviews framework conditions of HCD at both the system (cabinet-authorised) and national (within departments and ministries) levels. The functioning of South Africa's NSI is dependent on the interface between the human capital production pathways and innovation-driven SD. The sub-section reviews the means to strengthening of relevant HCD and other components of knowledge infrastructure.

The OECD (1997:9) defined human capital as "the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity". The fourth of the five TYIP SA DST (2008:5) key principles states that "sustainable capacity: the R&D scale-up must be consistent for the system to have the appropriate absorptive capacity, with each element (for example skills, capital spend) relying on others for the system to work". An explicit and proactive human capital policy is an important key issue for the knowledge ecology (Keller, 2004; Foray, 2010:103).

The TYIP shift to knowledge economy will require a planned, concerted, well-resourced and sustained human resource programme of action by all the relevant NSI policy-makers and performers. Table 4.7.2-1 outlines the HCD actions and outcomes desired by the DST (2008:9).

However, higher (and further) education and training are the responsibility of the DHET, not the DST.

Table 4.7.2-1: Human capital development actions and outcomes desired by the

South African Human capital development actions and outcomes	
Human capital development actions and outcomes	By 2018 South Africa will have: • 210 research chairs at universities and research institutions across the country by 2010 and 500 by 2018 (*58 were in place in 2006*) • About 6000 PhDs produced per year in all SET disciplines by 2018 • About 3000 SET PhDs/doctorates produced per year by 2018 • An optimal ratio of technicians and researchers • A 2.5 per cent global share of research publications (*2006:0.5 per cent*) • 2100 patent cooperation treaty international applications originating from South Africa *(2004:418)* • About 24000 patent applications at the South African Patent Office *(2002:4721)*

Source: DST (2008:9)

A discrepancy exists between the intentions of the NGP vision 2030 by EDD (2010) the TYIP of 2008 HCD actions in Table 4.7.2-1 and the Twelve Outcomes of government and the associated Delivery Agreements. The South African HCD system is locked into sets of inter-dependent 'pipeline jams' with piecemeal interventions having so far served only to make the supposedly 'fatigued' system more refractory to positive change (SA DST Ministerial Review Committee, 2012:144).

First, the 2010-2014 Performance Agreement (Delivery Agreement 5) between the President and the Minister of S&T and the Minister of HET stipulates reaching the following targets by 2014: 20 000 honours degree graduates; 4500 master's degree graduates; 1350 doctoral graduates; along with the provision of 100 postdoctoral fellowships (100 postdoctoral fellows are far below the 627 recorded in the official 2008/09 National R&D Survey). The Higher Education Management Information System (HEMIS) data by the DHET indicates that reaching the targets by 2014 should not prove to be insurmountable and, in some cases have already been exceeded in 2010.

Second, according to the NGP (EDD, 2010:278), South Africa produces 28 PhD graduates per million per year, which is low by international standards. The NGP EDD (2010:278) targets of 100 PhD graduates per million per year by year 2030, which translates to more than 5000 graduates per year against the figure of 1420 in 2010, while the TYIP targets about 6000 PhDs produced per year in all SET disciplines by 2018. The NGP (EDD, 2010:278) further states that "if South Africa is to be a leading innovator, most of these doctorates should be in science, engineering, technology and mathematics". The failure of human resource provision is the key weakness of the NSI, which represents a joint failure across government for which no short-term solution is in operation (SA DST Ministerial Review Committee, 2012:78).

According to the NGP EDD (2010:278), South Africa needs to increase the percentage of PhD qualified staff within the HEIs from the current 34 per cent level to over 75 per cent over 20 years; double the number of graduate, postgraduate and first-rate scientists and increase the number of African and women postgraduates, especially PhDs to improve research and innovation capacity and normalise staff demographics. The SA DST TYIP target 3000 PhDs in SET to graduate annually by the year 2018. The SA DST TYIP (2008:28) further states “South Africa will need to increase its PhD production rate by a factor of about five over the next 10-20 years”. As from 2005, universities in South Africa were rewarded quite significantly for producing more PhD graduates in all fields of science. In 2007, both the DST and the NRF set PhD targets for the country, though the targets were “slightly unrealistic and ambitious” (Mouton, 2013:2). According to the Academy of Science of South Africa (ASSAf, 2010) the current system, which is comparatively unproductive in terms of annual numbers of doctoral graduates (about 1000 per year), is severely resources stretched, limiting the ability of the HEIs to increase doctoral graduates five-fold as required by the SA DST TYIP (2008). Implementation of Delivery Agreement 5 can result in reaching the target for growth planned in national GERD as a percentage of GDP of 1.5% unattainable and would amount to a slow strangulation of the research side of the NSI.

According to qualitative case studies by CREST in Mouton (2013:2), four main imperatives in policies and strategies in PhD training in South Africa over the past 15 years are the quantity, quality, efficiency and transformation and equity. Policy and strategy documents by various bodies articulate the demand for an increase in PhD production in South Africa “symbolically” expressed in the 1997 education White Paper. For example “…symbolic policy texts are by nature potentially contradictory, ambiguous and open to multiple mediations and interpretations” (Kruss, 2003:69). The demand became explicit in the 2001 NP for Higher Education “but at that point no targets were set” (Kruss, 2003:69). In 2003, South Africa’s education department revised the national funding framework for universities and research Masters and PhDs as knowledge outputs were added to subsidies for research outputs. While there is no policy imperative that deals explicitly with quality and efficiency, Mouton (2013:2) notes that quality has been assumed in all of the policy documents. “The tacit approach is perhaps because the notion of ‘quality’ is an elusive concept that cannot easily be measured through standard indicators. There seems to be an assumption that our system is inefficient" (Mouton, 2013:3). The most explicit statement of demand for greater efficiency was in a 2012 Green Paper and the NDP: Vision 2030 by NPC (2011b), which give a target of a 75% throughput rate for higher education. In conclusion, Mouton (2013:3) states "it is essential that universities achieve the right balance between national demands and good practice in supervision. Ultimately, universities cannot simply slavishly and uncritically follow and implement such demands. They need to protect the academic project (and their supervisors), which is the pursuit of excellence in everything that we do." According to this research policy, ambiguities and contradiction give rise to contestation and competing interpretations as policy moves to institutional level and the level of practice.

Where there are measures in place, for example the Dinaledi Schools or SARChl, there are no publicly available evaluations of the projects. The SARChl is one of the most effective antidotes to the heavy pressure of teaching on capable researchers. The SARChl focuses on natural sciences, with reference to important areas such as education and service delivery and, therefore, the initiative needs to be re-configured and implemented in other priority areas critical for South Africa's development. Figure 4.7.2-1 outlines uncertainty of the South African HCD pipeline in the NSI. One of the key deficiencies identified is the limited analysis of the NSI performance in terms of the educational system, despite the plentiful official statistics, which should include variables such as regional location of schools, race, class, and gender and subject choice.

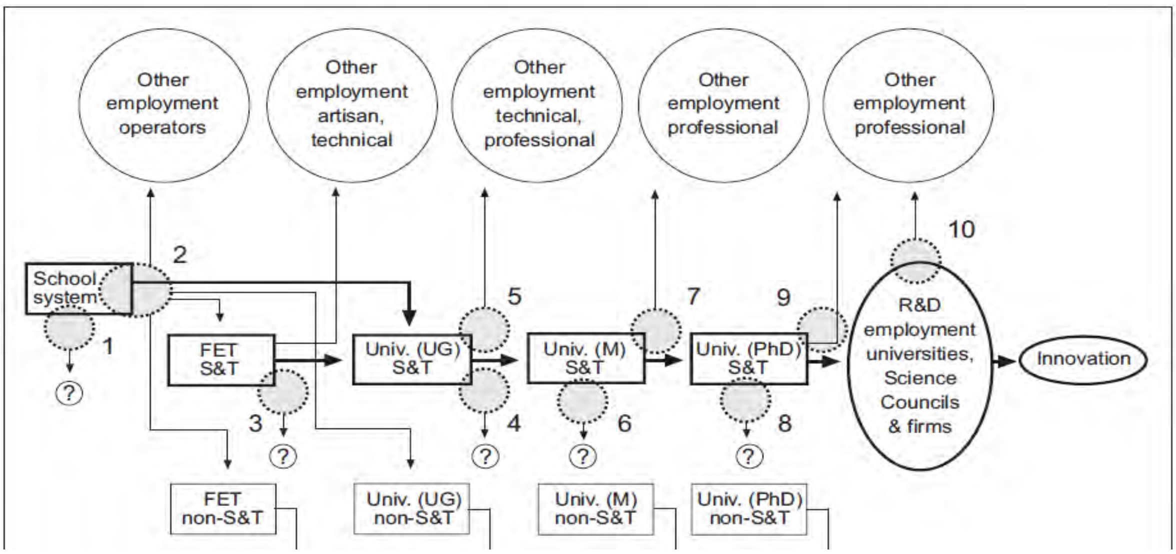


Figure 4.7.2-1: Human capital pipeline in the NSI
Source: OECD (2007b:151)

In summary, as shown in Figure 4.7.2-1, the 2007b OECD Country Review indicates that uncertainty can be attributed to the (i) high dropout rates from the school system at [1] due to economic and social reasons, such as poverty and HIV/AIDS; (ii) relatively low number of students move into scientific and technological subjects in the further education and training (FET)[2]; (iii) considerable proportion drop out ([3] and [4]) among those who do move on to further/higher education in scientific and technological fields; (iv) large proportion move directly to employment rather than to postgraduate training ([5]) among those who graduate with first degrees in scientific and technological subjects; (v) high drop-out rates remain at postgraduate level ([6] and [8]); and (vi) high number among those who graduate at Master's or PhD levels, move directly to employment outside R&D are indicated in ([7] and [9]). This is because of more attractive prospects than proceeding from a Master's degree, doctoral or post-doctoral research (OECD, 2007b:151-152). Harvey (2000:3) notes a causal link implies that HEIs "should be able to provide graduates with some sort of package of attributes that meshes with what an employer is looking for".

4.7.3 The NSI Knowledge Infrastructure and Knowledge Transfer (Items Ix & Xi)

This sub-section reviews the NSI knowledge infrastructure and knowledge transfer and maintains that there is a gap in South African knowledge research infrastructure. To realise the GERD target of 1.5% set by the South African government, will require expanding as well as restructuring the existing infrastructure. The development intent of South Africa's STI policies was declared in the White Paper on S&T in 1996 by the DST, which set precedence for a system for the creation and application of knowledge. A case for the establishment and step-wise roll-out of 'provision of infrastructure' (DST, 1996:19) roadmap exists in South Africa. Strong knowledge institutions are the best indication of sound infrastructure of the South African NSI.

From this research perspective, knowledge infrastructure, broadly refers to a set of HEIs and vocational colleges, state laboratories and associated utilities such as reliable communications and transport, energy supply, and especially ICTs such as broadband and computing power. Using a strict perspective, knowledge infrastructure refers to "the specific requirements for building and sustaining an innovative society based on the value chain of knowledge generation, transfer, storage and assimilation (SA DST Ministerial Review Committee, 2012:156). A sound knowledge base is important for innovation (Sutz, 2007:331). In an increasingly knowledge-based economy, investment in knowledge output in the form of research offers valuable dividends because:

> Knowledge and innovation are increasingly recognised as sources of global competitiveness and economic well-being. Research on systems of innovation has shown that a country's capability to introduce new and innovative products and services that contribute to its wealth is related to its research activities, to its proportion of scientists and engineers, to its policies and programs supportive of research and its commercialisation (Doutriaux & Sorondo, 2005:2).

The key to the successful transfer of new ideas is the "establishment of a knowledge network on innovation" (Galimberti, 2005:11). Human capital for innovation is a focal point in any knowledge ecology policy (Niosi, 2002:292; OECD, 1997:11; Foray, 2010:103). In addition, scientific and technological knowledge is an essential element of innovation, and the foundation for economic development (OECD, 2003:9).

The OECD (2007b:19) note that: "scientific knowledge can play an essential role for innovation and economic development". Furthermore, the generation, exploitation and diffusion of knowledge have been fundamental to the economic development and well-being of nations or regions (Reinert, 2007; Lember, Kalvet & Kattel, 2014:84). In the management of knowledge infrastructure, two guiding interventions by the South African government have been utilised to address backlogs and planned (non-cyber) infrastructure for the future, namely: (i) the National Research and Technology Infrastructure Strategy developed by the NRF in 2004; and (ii) the study commissioned by NACI in 2006, which is in current use as a baseline for funding research infrastructure applications, the National Equipment Programme (NEP) and the National Nanotechnology Equipment Programme (NNEP) in 2010.

With respect to cyber-infrastructure in South Africa, a significant public investment in high-performance computing, fast broadband networks and very large database storage has been made available in the decade, mostly through the Meraka Institute at the CSIR. Although Pinto and Slevin (1988:483-514), states "knowledge management is not about technology", in policy making, ICT can be utilised to replicate historical processes, data management, for storing emerging knowledge, best practice, and standards to avoid fossilisation.

Serra (1613), cited in Lember et al. (2014:84) established that Venice, a natural resource-poor was at the centre of the world economy due to the great use of knowledge in various ways in comparison to Naples a resource-rich city. As a result Serra (1613) concluded that "…effective government, when it occurs to perfection in any kingdom, will undoubtedly be the most powerful cause of all of making it abound in gold and silver". Serra's work was appreciated by Shumpeter (1934) whose main argument was that economic development is driven through a dynamic process in which new technologies, skills and industries play a key role (Lember et al., 2014:84). In the systematic approach, this research is of the view that effectiveness of the South Africa's NSI will depend on a balanced combination of resource based and knowledge economy.

4.7.4 Mode 2 Knowledge Production

In Mode 2 a term coined by Gibbons (1998), knowledge is produced 'in the context of application' by so-called Trans disciplinary collaborations, which is not meant to replace Mode 1. Attributes of Mode 1 include academic context; disciplinary homogeneity; autonomy and traditional quality control (peer review). Five attributes of Mode 2 are: knowledge produced in the context of application; Tran's disciplinarity; novel quality control; reflexivity/social accountability; and heterogeneity and organisational diversity (Goransson & Brundenius, 2011). Compared to Mode 1, Mode 2 knowledge is rather a dialogic process and has the capacity to incorporate multiple views, reflexivity. This reflexivity relates to researchers becoming more aware of the societal consequences of their work ('social accountability'). Mode 2 knowledge is also generated in a context of application and is trans-disciplinarity, which refers to the mobilisation of a range of theoretical perspectives and practical methodologies to solve problems.

Mode 2 knowledge is produced in a variety of organisations, resulting in a heterogeneous practice. The range of potential sites for knowledge generation includes not only universities and colleges, but also research centres, government agencies, industrial laboratories, think-tanks and consultancies. These sites are linked through networks of communication and research is conducted in mutual interaction (Gibbons, Limoges, Nowotny, Schwartzman, Scott and Trow, 1994; Hessels & van Lente, 2008; Goransson & Brundenius, 2011).

4.7.5 NSI Performance Measurement and Evaluation (Item X)

This research shares a similar view with the SA DST Ministerial Review Committee (2012:83) that robust instruments for NSI performance measurement and evaluation are required for an effective management information system (MIS)/policy management information system (PMIS). In this research context, a MIS/PMIS provides the people, policies, procedures, systems (manual or computer-based) to accomplish the basic tasks involved in policy objectives, work definitions, communication, scheduling, budgeting, baseline, monitoring/reporting, quantitative and qualitative analysis and corrective action (Thoms & Kerwin, 2004:1016).

An MIS maybe viewed as the primary vehicle developed as part of the policy plan for integrating policy parameters with the strategic direction, as well as the infrastructure which provides a repository of information used to keep stakeholders informed about the policy progress (Jaafari, 2004:309; Cleland & Ireland 2007:297. Figure 4.7.5-1 is a sample MIS relevant in an NSI design.

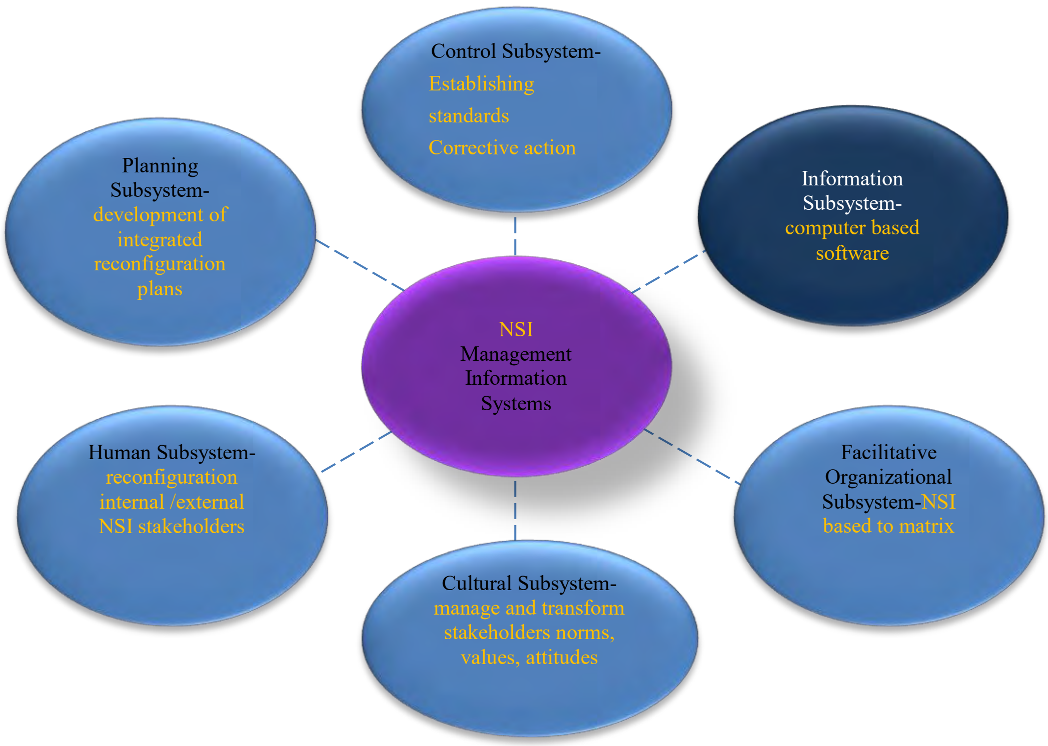


Figure 4.7.5-1: Proposed management information system and information subsystem
Source: Adapted from Cleland and Ireland (2007:297)

Furthermore, Figure 4.7.5-1 can be utilised in assessing policy and programmes impacts, alongside other effects such as scientific progress, economic and policy impacts (Harayama & Nitta, 2011:13). Although the series of R&D, innovation surveys and policy recommendations by the White Paper on S&T (2006) have been implemented, the MIS/PMIS requirements of the NSI nevertheless, remain poorly served (SA Ministerial Review Committee, 2012:83). In South Africa, there are many databases, but little information in the public domain, resulting in a lack of coordination of S&T information and indicators, as well as the inevitable duplication and gaps.

This research proposes some categories of MIS, which can be used as a source of information for the South African NSI, indicated in Table 4.7.5-1. The argument is in the favour of the development of decision-support tools such as STI observatories for policy-making based on evidence-based information for strategic analysis. The SA DST Ministerial Review Committee

(2012:160) also proposes that tools can be used for designing and implementing effective SD policies and action plans, and for assessing the efficacy and impact of existing STI policies.

Table 4.7.5-1: Proposed categories of MIS as a source of information for the NSI

CATEGORIES OF PMIS AS A SOURCE OF INFORMATION	
• *Organisational guidance or support information in the MIS could be*: - Policy manual. - Policy management methodologies. - Organisational policies for Policies. - Organisational procedures for Policies. - Organisational briefings on Policies capabilities and implementation. • *Historical information in the MIS could be*: - Files from other Policies that contain performance data and best practices. - Proposal, quotes, and bids on the Policies. - Policies plans from prior Policies. - Marketing presentation for the policy. • *Old files from the current project that are no longer needed for the policy's on-going work could contain:* - Old or suspended materials (Schedules, expenditures, briefings, plans). - Records of former policy team participants. - Closed out contracts or closed invoices. - Inactive files for correspondence. - Suspended policies, procedures, standards, and decision papers.	• *Current policy information in the MIS could be*: - Contracts for easy access by the project manager. - Project charter. - Specifications on the project products. - Statement of work. • *Drawings, schematics, and illustrations related to the project*: - Schedules. - Budgets. - Risks. - Communication plans. - Risk plans. - Risk assessments. - Policy correspondence. - Policy internal policies and procedures. - Approved vendor list. - Names and addresses of key organisational people. - Functional or operational plans prepared by the functional departments. - Policy diary and Briefings. - Standards. - Time cards for policy team. - Issue log and Action item log - Lessons learned.

Source: Cleland and Ireland (2007:303)

The development of decision-support tools presented in Table 4.7.5-1 requires close cooperation among the NSI actors. The DST has officially designated organisations such as the CeSTII to fulfil an observatory role, which constitutes a key infrastructural component within South Africa's NSI. South Africa has an estimated 14 000 remote and distributed sensing and measuring devices. However, the data collection and storage methodologies used for the devices are in the main archaic and ineffective.

In the proposed South African Office of Research and Innovation Policy (ORIP), soon-to-be-available decision-support tools such as the Research Information Management System (RIMS) will provide appropriate linkages and collaborative initiatives with other tools such as the Higher Education Management System (HEMIS) and NEXUS in the NRF. In South Africa, NACI collates existing information into the S&T Indicator series, but adds very little in the way of further analysis. This research is of the view that the NSI knowledge infrastructure will be improved by the RIMS, once fully implemented (Ministerial Review Committee, 2012:85-88). The RIMS will provide an integrated real-time information (capture data and produce reports on research inputs, outputs and processes) on South Africa's current highly fragmented R&D activities of publicly-funded institutions (HEI and science councils) and provide specific indicators to monitor the overall performance of the part of the NSI (SA DST Ministerial Review Committee, 2012:88-89).

The HEMIS decision-support tool is the successor to the South African Post-Secondary Education (SAPSE) system. In conjunction with the Research Outputs Database (ROD), HEMIS is central to the relationship between the DHET and the HEIs, as the means for determining subsidy payments. However, at present, the HEMIS is not resourced to provide such services and resources and has less than a handful of dedicated staff. Therefore, this research shares a similar view with SA Ministerial Review Committee (2012:83-161) that HEMIS and the ROD databases should be made available to policy analysts, academic, researchers and students to gather data and information.

The ability to rate research groups is another key dimension that is missing in the current South African NSI MIS/PMIS. The current global practice is to rank individual researchers, of which South Africa is one of few countries that undertakes the ranking. However, the rise of multidisciplinary and trans-disciplinary research adds to this research case for the development of a different system of appraisal that recognises the myriad forms of academic and research excellence. The Academy of Science of South Africa (ASSAf, 2010) has made much progress in setting up the DST-subsidised, free-online, fully-indexed electronic publication platform, SciELO-South Africa, designed to render a large part of the content of South Africa's scholarly journals visible worldwide in order to increase access to information infrastructure and enhance collaboration.

In South Africa, some decision-support tools such as the National Research and Education Networks (NRENs), the public-sector networks, South African National Research Network (SANReN) and the Tertiary Education and Research Network of South Africa (TENET) have been problematic since conception. For instance, even though increasingly addressing much of the national connectivity demands, SANReN has limited its usefulness because it does not have a fast link internationally. As a step in the right direction, the intelligent use of the NRENs can make a big difference in standardisation and common access to information.

4.7.6 Research within the South African national system innovation

In this research context, the building and expansion of a strong public research sector in South Africa is an issue, which should be addressed to the stage of commercialisation and with positive impact to the construct of SD within the NSI. The term 'research' is rooted in the term 'search' to examine thoroughly. The Webster Collegiate Dictionary (2011:1042) defines 'research' as an "act of searching closely and carefully or intensive searching". This research, defines the term 'research' according to the OECD (2002b:30):

> Comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of human kind culture and society, and the use of this stock of knowledge to devise new applications.

The Frascati Manual further distinguishes between the following three types or modes of research. The first is the basic research, which is experimental or theoretical work, undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view (OECD, 2002b:77). The results of basic research are not generally sold, but are usually published in scientific journals or circulated to interested colleagues (OECD, 2002b:77). The second is the applied or strategic research, which is original investigation undertaken in order to acquire new knowledge. Applied research is directed primarily towards a specific practical aim or objective (OECD, 2002b:78). The OECD (2002b:78) underscores that "the results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods or systems". The third is experimental development, or systematic work that draws on knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed (OECD, 2002b:79).

The overreliance on basic research can be attributed to a lack of funding, which is reinforced by poor strategic planning, monitoring and evaluation and programme improvement mechanisms of the industry needs. Brown, Blake, Brennan and Bjarnason (2003:8) note that HEIs "formulate their missions along traditional teaching and research lines" in the absence of alternative strong fund signals and incentives.

'Research utilisation' in a narrow sense refers to the economic or commercial usefulness of research. The broad sense refers to any form of use that the results of scientific research are put to, economic or commercial usefulness as well as social usefulness and political usefulness (political decision making) (CHE, 2004:15). South Africa has a well-developed base and network of public science research institutions, which should be maintained and strengthened in building long-term STI capabilities illustrated in Figure 4.7.6-1.

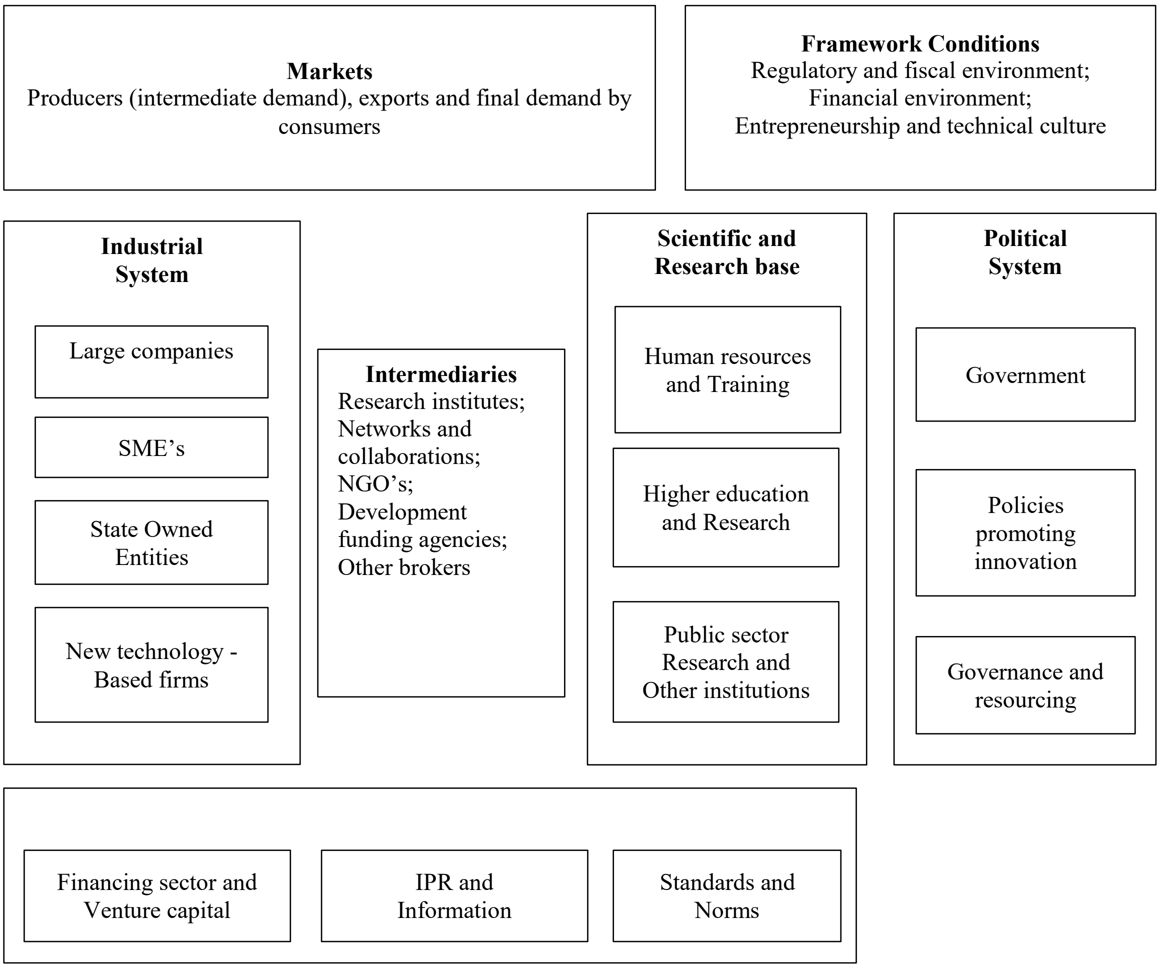


Figure 4.7.6-1: Major components of the National System of Innovation
Source: adopted from SA DST (2011:14)

As shown in Figure 4.7.6-1, the key requirements for expanding and strengthening the South Africa's STI base include: HCD, STI infrastructure capacity and coordination, integration into the global R&D value chains and eliciting of the HEIs and the private sector R&D efforts (SA DST, 2011:13). Table 4.7.6-1 presents five stages of knowledge utilisation adopted from OECD, (2005b:28) formerly adapted from Knott and Wildavsky (1980); and Landry, Lamari and Amara, (2003:194).

Table 4.7.6-1: Stages of knowledge utilisation

STAGES OF KNOWLEDGE UTILISATION	
1. Reception	"I received the university research pertinent to my work"
2. Cognition	"I read and understood the university research that I received"
3. Discussion	"I participated in meetings for discussion and popularization of the aforementioned university research"
4. Reference	"I cited university research studies as reference in my own professional reports or documents"
5. Effort (adoption)	"I made efforts to favour the use of university research results"
6. Influence	"university research results influenced decision in my administrative unit"

Source: OECD (2005b:28) adapted from Knott and Wildavsky (1980); cited in Landry, Lamari and Amara (2003:194)

The five stages of knowledge utilisation in Table 4.7.6-1 can be adapted by the HEIs to increase research utilisation and learning by the private sector in South African NSI context. Furthermore, Table 4.7.6-2 provides a picture of the NSI main actors involved in transfer and commercialisation of research by OECD and UNDP (2002).

Table 4.7.6-2: Suggested actors and possible functions of key roles

SUGGESTED ACTORS AND POSSIBLE FUNCTIONS OF KEY ROLES					
	Political support	**Financial support**	**Technical support**	**Administrative/ management support**	**Facilitator/ mediator**
Government	X	X		X	
NGOs	X	X	X	X	
Private sector			X	X	X
Professional associations	X		X	X	X
Media	X			X	X
Academic research organisations			X	X	X
foundations		X		X	X
Multi- and bi-lateral support	X	X	X	X	X

Source: OECD and UNDP (2002)

Table 4.7.6-2 also illustrates the roles played by each NSI actor in terms of political, financial, technical and management support, as well as what actors can best assist as facilitators/mediators applicable within the South African NSI.

Alberti and Bertucci (2006:20-21) describe four different types of research/knowledge transfer as shown in Table 4.7.6-3, namely: emulation, dissemination, harmonisation and imposition. The first is emulation, which is voluntary in nature and can be used as a tool for political innovation, where knowledge of external models inspires internal decisions. The second is the dissemination of transfer that requires the existence of transnational networks for acting as platforms for the generalisation of policy solutions. Third is the harmonisation, which entails the existence of a network of motivated and authoritative actors such as the OECD. In harmonisation, transfer and convergence arises, from the recognition of interdependence. Fourth is the imposition in which external agent sets the objectives, instruments, evaluation tools and even provides the necessary resources for the implementation of the policy. For example, international donors impose significant conditions in exchange for financial or technical support.

Table 4.7.6-3: Policy transfer types variables

POLICY TRANSFER TYPES VARIABLES		
Institutionalisation and coercion	**Similarity and success**	**Political commitment**
Emulation: Internal decisions are inspired by external models. The process is voluntary and the initiative local.	*Emulation*: a foreign policy, process or practice is borrowed in all items.	*Accommodation*: transfer induces changes and reforms compatible with domestic institutions.
Dissemination: the existence of professional networks explains the sharing of knowledge and the generalization of solutions to similar problems.	*Synthesis*: Implies a process of policy creation by the combination of elements taken from different contexts.	*Transformation*: Transfer implies the modification of the previous pattern of action.
Harmonisation: Based on the existence of common institutions. Mainly focused on regulation and policy design and implementation.	*Influence*: the foreign model serves as a mere inspiration. The process of policy design is basically local.	*Inertia*: political will change does not exist. Local constituencies follow previous patterns, avoiding external models.
Imposition: External actors impose objectives and provide resources. Dominant model in development policies.	Abortive transfer: The transfer is blocked by veto actors.	Retrenchment: Transfer is considered a threat, which strengthens local opposition to innovation and reform.

Source: Alberti and Bertucci (2006:20-21)

The four different types of research/knowledge transfer shown in Table 4.7.6-3 can be strengthened through approaches and methodologies for best practices in transfer of innovation. Table 4.7.6-4 summarises the strengths and weaknesses of transfers of best practices.

Table 4.7.6-4: Strengths and weaknesses of transfers of best practices

STRENGTHS AND WEAKNESSES OF TRANSFERS OF BEST PRACTICES	
Practitioner to Practitioner	
Strengths	*Weaknesses*
• Comparative experience • Practical solutions/convey knowledge nuance • Mutual trust/personal high-level investment • Creates sustainable network • Creates opportunity to institutionalise • Expands access to experience • Builds capacity for both parties • Helps define responsibility	• Costly • Borrower/lender – time constraints • Scale limiting/not scalable • Not present at implementation • Lack of criteria/standard retraining given focus • on success of innovation • Lack of tactical tools • Not all dimensions are covered • Dependent on an individual being static
Information Sharing	
Strengths	*Weaknesses*
• Can be done through awards • Relatively inexpensive • Can be peer-to-peer	• Access to information (if held privately) • False information/incorrect/misleading • Language barrier (may be easily overcome) • Lack of background country for innovation • Lack of legal infrastructure to support sharing
Problem Solving	
Strengths	*Weaknesses*
• Similar to practitioner-to-practitioner • Group dimension • Wider impact/richer information • Cooperation oriented/conflict diversity resolution/overcomes positional bias • Collective learning process	• Language barriers/isolation • Risks being inconclusive (can overcome through institutionalisation) • Remote locus of responsibility • Time consuming
Transfer Guidelines	
Strengths	*Weaknesses*
• Possibility of developing strong framework	• Can give passive role to recipient • False sense of security
Training	
Strengths	
• Systematic/clear knowledge transfer • Rapid deployment • Adaptable to any stakeholder in the process	
Experts	
Strengths	*Weaknesses*
• Can be deployed quickly	• Can be inconclusive, supply driven • Likely lacks knowledge of nuances

Source: Alberti and Bertucci (2006:20-21)

Figure 4.7.6-2 illustrates the mechanisms for knowledge flows that include joint industry research, public/private sector partnerships, technology diffusion and movement of personnel required for innovation to take place. Within the NSI, knowledge transfer takes place through codified and tacit forms (Edquist, 2005; OECD, 2007b). Codified forms include scientific publications, registered designs, patents, copyright, plant varieties, registered breeds and organisms. Tacit knowledge transfer involves non-formal interaction, such as research translation into formal publications, and

HEIs graduates circulating within the NSI, while absorbing and transferring knowledge (Edquist, 2005; OECD, 2007b).

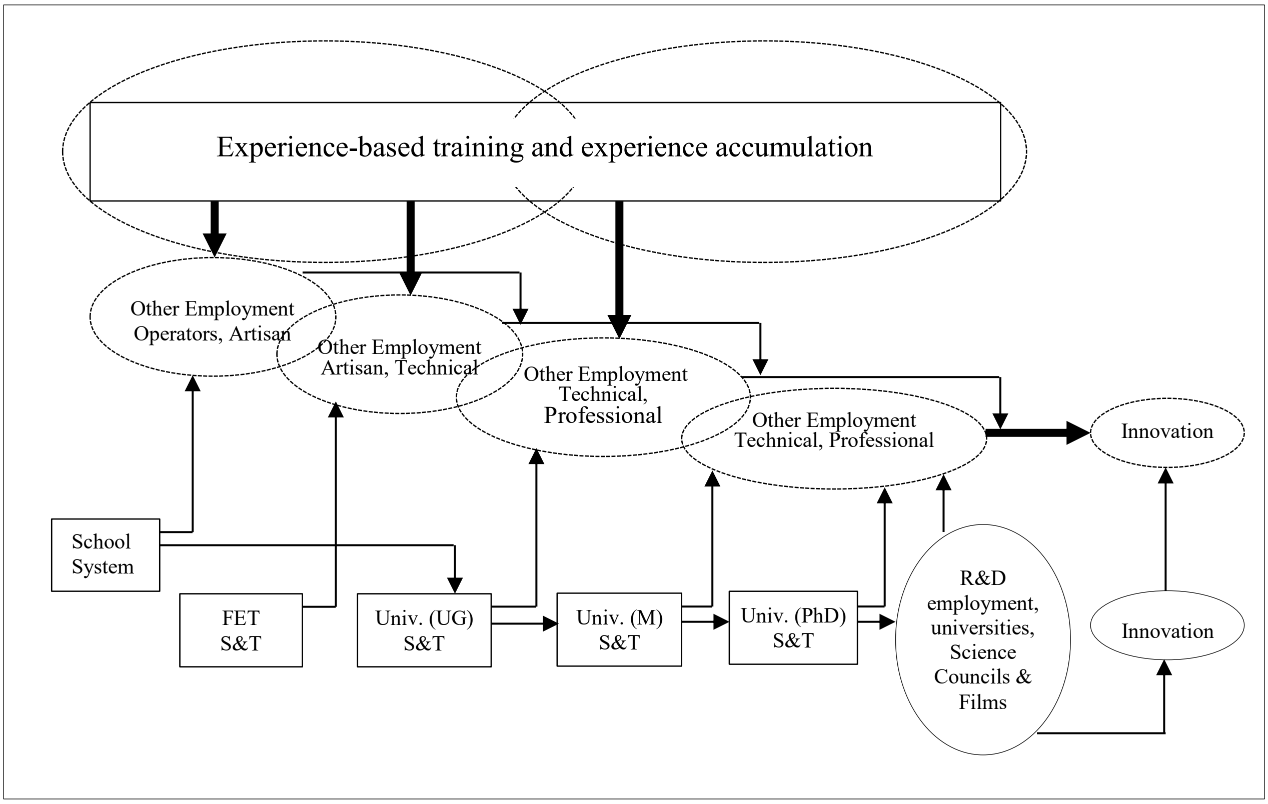


Figure 4.7.6-2: Experience-based training and experience accumulation
Source: OECD (2007:115)

In South Africa, the NRDS of 2002 set out three research pillars. First was the innovation pillar for the establishment and funding of technology missions. The second involved increase in the investment pillar, aimed at increasing the science base and research. Third was a focus on S&T policy pillar, which has resulted in initiatives for the establishment of funding drivers for transforming the research and innovation system, such as changes in the overall system of funding and the introduction of special funding strategies.

The third of the five TYIP SA DST (2008:5) key principles states that “critical mass: investment in key research must be made at a critical mass”. Indicative figures for 2014 research in South Africa shows that the type of R&D is estimated to be 10% basic, 45% applied and 45% experimental development, (2012 figures for were 25%, 44% and 31% respectively). The South African government will account for 75% of the funding used for a total expenditure of R4 billion (half of the amount is grants, and the other half as contracts), business/industry 15%, foreign sources 5%, and own sources 5% (2013 figures are 71%, 4.4%, 12.5% and 12% respectively). The spread of funding over fields has been overwhelmingly in favour of the natural SET at 20% each, physical, chemical and earth sciences about 10% each, biological sciences at 5%, and social sciences at 5%.

South Africa's research infrastructure programmes such as the SALT and MeerKAT have attracted attention in some large international astronomy with the possibility of South Africa hosting the future SKA (African Union, 2010:1). The MeerKAT telescope was commissioned in 2013. South Africa is a partner in the Cherenkov Telescope Array (which is under development) and its role in the Southern Oceans and Antarctica has been recognised. Similarly, programmes addressing expensive research requirement for implementing the Nanotechnology Strategy have been devised in South Africa. The DST is apparently in the process of developing a framework and guidelines regarding membership of and access to large international research infrastructure facilities. The membership and access to facilities such as the European Organisation for Nuclear Research (CERN), Joint Institute for Nuclear Research and various synchrotrons are presently governed by separate agreements which are accompanied by substantial annual investment. Table 4.7.6-5 summarises the key elements that should be targeted with the additional public funding for science and research in South Africa.

Table 4.7.6-5: Key activities for deployment of additional public investment in R&D

THRUST AND OBJECTIVES	SUMMARY OF KEY INVESTMENT ACTIVITIES
Basic research and knowledge generation	**Recapitalisation of science councils:** - Increase the ratio of government funding to support budget of science councils versus other sources of income - ARC; MINTEK; Council for Geoscience; CSIR; HSRC; MRC; Southern African Biotechnology Network **Incentives to boost research capacity in universities:** - Improve qualification profile of academics and research staff - Expand and establish new research chairs - Centres of excellence programme.
Development of high-level human capital	**General national skills requirements:** - Improvements to mathematics and science teaching - Promotion of careers in science, engineering and technology fields and science in society **Bursaries and support for higher qualifications in science and research:** - Expansion of honours bursaries - Expansion of postdoctoral fellowship - Extension of bursary support to increase masters and doctoral graduation rates **Transformation of the science workforce:** - Activities to drive transformation within the science workforce and in human capital development - Dedicated research support for women and young researchers

THRUST AND OBJECTIVES	SUMMARY OF KEY INVESTMENT ACTIVITIES
Critical research equipment and infrastructure capacity	**Critical infrastructure to enhance research performance:** - Scientific research equipment (national equipment programmes; national research facilities) - Specialised laboratory facilities (development of a Cape health technology park; national preclinical drug development platform; upgrade of Houwteg) - Cyber infrastructure (expansion of South African National Research Network) - Large high-end infrastructure and global infrastructure (titanium test plant and related laboratory equipment). **Technological infrastructure in specific service delivery domains:** - National Health Laboratory Services - South African Weather Services - National Agricultural Public Assets at Agricultural Research Council - National biodiversity facilities at the Southern African - Biotechnology Network.
Support commercialisation, technology development and transfer	**Enhancing support and incentive for private sector R&D** - The TIA fully operational - Increase uptake and effectiveness of the current R&D and innovation incentives - Increase incentives to promote cross-sectoral funding for R&D Measures to improve efficiency for utilisation of research results: - Leverage procurement by state-owned enterprises. - Effective Intellectual Property regulation - New institutional structures
Leverage international R&D investment	**Promote SA as R&D location within the FDI promotion framework:** - Actively target technological based investment projects for FDI - Engage foreign venture capital, the international philanthropic organisations, and the local corporate social responsibility market **Boost local capacity to absorb international R&D opportunities:** - Introduce dedicated programme for international training for high-level human capital and collaborative research - Mega science projects and international partnerships.

Source: DST (2011:29-30)

Table 4.7.6-5 further illustrates the rationale for public funding for R&D in South Africa, whereby public investment will be applied, for instance, in the basic research and knowledge generation. An additional government investment of R5.7 billion from 2011-2014 is therefore proposed, shown in Figure 4.7.6-3 adopted from DST (2011:30).

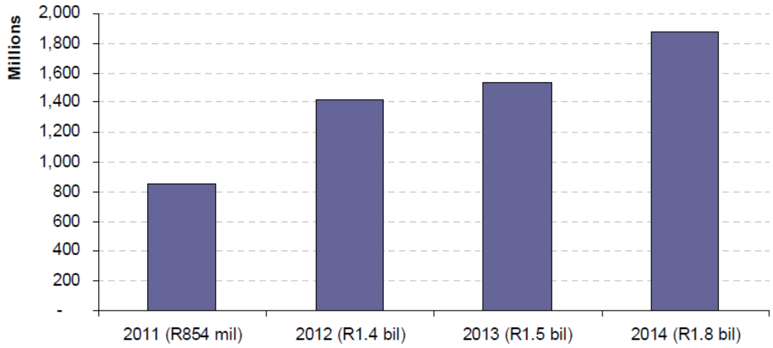


Figure 4.7.6-3: Projected amounts of required public R&D investment 2011-2014
Source: DST (2011:30)

Additionally, Figure 4.7.6-3 indicates an yearly increase in proposed government investment in public R&D. Enhancing the NSI and increasing R&D investment in South Africa will require a combined additional investment of R14 billion to R18 billion from the private sector and international sources from 2011-2014 (SA DST, 2011:2-3).

4.7.7 The Concept of Innovation

Innovation is an integral element of the NSI, which is a subject that has been researched from different scholarly and organisational disciplines and traditions. However, commercialisation of research for SD has not been undertaken in South Africa. The literature indicates that there are no common innovation contextual denominators to bridge different research traditions, models and innovation theories (Kim, 1997; Trott, 2005; Goffin & Mitchell, 2009). Therefore this research contributes towards the theory of innovation and related frameworks.

Smith, Stirling and Berkhout (2005) formulated three components that can be used to determine innovation potential and, consequently, research commercialisation. First is the system pressure and articulation of particular problems or development trajectories. Second is the availability of resources, while third is the coordination of regime pressures across and within the NSI. However, this research has established that how the three components are connected or put in practice is somewhat elusive and scattered.

Innovation has been viewed by scholars as the main driver of enterprise longevity, the engine of economic growth and sustainability for example, Schumpeter (1934), Drucker (1998), OECD (2003:9), OECD and Eurostat (2005) and Trott (2005). Marx was the first to suggest that innovations could be associated with waves of economic growth (Trott 2005:7, while Freeman

(1982:9), cited in Trott (2005:10), concludes that "…not to innovate is to die". Since then scholars such as Schumpeter (1934), Freeman (1987:1995), Lundvall (1992) have argued the long-wave of the importance of innovation. In this research context, innovation has both social and economic impacts and successful implementation of invention results in innovative products and services. Innovation also gives rise to new markets, generating growth for enterprises, and creates customer value, increased "knowledge stock", higher and better quality of living standards (Kotler 2000:34; Milbergs et al., 2007; Goffin & Mitchell 2009:1).

4.7.8 Defining Innovation

It may be argued that innovation is not a concrete object. Innovation is thus a concept (Pollitt, 2011:35), or a word that labels a concept - a noun (Lundvall, Muchie & Gammeltof, 2003:4; Rogers, 2003; Fagerberg et al., 2005:7). There is no widely accepted or common definition of what counts as an innovation. Therefore defining innovation can differ depending on the perspective, approach, an idea, setting and the purpose (Hannah, 1995).

Unlike inventions "most innovation projects in most firms do not involve great novelty" (Hippel von, 2007:411). Hence 'invention' can be used to refer to novelty, leaving innovation to encompass any form of adoption of a device, system, policy, practice, program, process, product or service that is new to the adopting organisation (Damanpour, 1991:556; Nowotny, 2011:13; Rogers, 2003; Fagerberg et al., 2005:7).

The Webster Collegiate Dictionary (2011:942) defines innovation as "making changes to something established by introducing something new". Schumpeter (1934) defines innovation as a process of creative destruction that is the ability to achieve new combinations that have to compete with established combinations (discontinuity with the past), where new products, services, activities, jobs and industries are created and old one cease. Schumpeter (1939) later defined innovation to be a"…process of converting new or existing knowledge to value for the benefits of individuals, groups or communities". In public administration innovation in agenda-setting theory can be defined "as the ability to open the policy window by policy entrepreneurs" (Bekkers et al., 2011b:27-28). The OECD & Eurostat (2005:46) view innovation as:

> The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.

In the aforementioned definitions, one common characteristic of an innovation is that of implementation. Overall, this research views innovation as the capacity to generate, acquire and apply knowledge for sustainable development in South Africa within the NSI.

4.7.9 Types of Innovation

Different kinds of innovations include techniques or processes that produce new products and those that alter the methodologies or processes for value creation (Van de Ven & Rogers, 1988; Bekkers et al., 2011b). Innovation can be prospective (rational and intentional) or retrospective (muddling through) (Alberti & Bertucci, 2006:12). The literature attempts to classify innovations, which are not exclusive and correlate to each other, but vary to some extent (Schumpeter 1947; McDaniel 2002; Fagerberg et al., 2005; Alberti & Bertucci, 2006; Moore & Hartely, 2008; Hartley, 2005). Innovation in LDC particularly in low-income countries tend to focus on absorptive capacity, incremental innovation, in low and medium technologies and in product as opposed to process innovation (Edquist, 2001:11).

The acquisition of absorptive capacity is a type of innovation, which in LDC is associated with the accumulation of investment in R&D and in HCD (Cohen and Levinthal, 1990:136-140), Liu and White 2001:1094; Kim, 1997; Edquist, 2001:11; Criscuolo and Narula, 2002:2006-2014). Absorptive capacity provides an environment for engaging in "innovative technology-developing tasks" (Ely & Bell, 2009:24; Wamae, 2009:203). Nevertheless, the complex facets associated with absorptive capacity have not been well been researched in developing economies. Similarly, little prominence has been attached to the concept of absorptive capacity for SD in the African region.

Innovation can be differentiated in terms of incremental versus radical innovation, which can affect institutional competencies in different ways (O'Sullivan & Dooley, 2009). Trott (2005:45) observes that radical versus incremental is a matter of perception and subjective judgment. Incremental innovation is characterised by technological learning, making minor changes on existing competencies and focuses on addressing existing needs and wants (Dutrénit, 2004; O'Sullivan & Dooley, 2009). Radical innovation can be viewed as a form of "supply–push process", which is competence destroying, thereby evoking new markets before potential need or want have been articulated (Markides & Geroski, 2005). Unlike incremental, radical innovation are characterised by long gestation periods and entails greater risks and uncertainty. Literature indicates that LDC are more likely to engage successfully in incremental than in radical innovations (Dutrénit, 2004:221; Wamae, 2009:203).

Innovation can also be classified to encompass a wide range of changes in institutional activities both tangible and non-tangible, such as process, product, services, organisational and institutional, position and strategic, governance, rhetorical, marketing, conceptual business model and rethinking the underlying mental models and paradigm (O'Sullivan & Dooley 2009). The aforementioned innovation can relate to the introduction of new products, management methods and techniques and new working methods. The replacement of "just-in-case" production structures with "just-in-time" production is supply driven innovation (Mortensen, 2008). Robertson, Pol and Carrol (2003:460) classify sectors by technology intensity such as between high, medium, or low-technology industries in a way that is operationally meaningful. Business model innovation can be used to describe the key components of a given business in creating and capturing value (Mortensen, 2008). The literature shows that a link between the various types of innovations in Sub-Saharan Africa is under-researched. Most LDCs invest very little in scientific and technological research. The average investment of the countries is around 0.5 % of GDP, which is five to six times less than that of industrialised countries (WEF, 2013:12).

Classifying innovation in terms of closed innovation is characterised by the reliance on internally generated R&D activities of an institution (Chesbrough, 2006:1; Shipp, Stone, Rose & Lal, 2008:6). Granovetter (1973) used the concept of open innovation to refer to "the strength of weak ties". While Chesbrough (2006:1) views open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively". Open innovation consist of interactive, non-linear nature, where learning and adaptation, which are conditioned by multiple, accumulative inputs both intentional and fortuitous (Chesbrough, 2006:2-3). Active management (boundary-spanning activities) is required to organise the interconnections because innovation is viewed to take place in the 'grey, informal', 'free spaces' area between exploitation and exploration (Granovetter, 1973; March 1999:5; Edelenbos & Klijn, 2006).

Srininvas and Sutz (2008:134-138) analysed innovation as a means of resolving local challenges and found that there was a lack of non-existing knowledge and inaccessible to obtain non-existing products and processes. This research explores the concept of innovation at the macro level, while making reference to the macroeconomic level as depicted in Figure 4.7.9-1. The implication of classifying innovation can be attributed to the need for South Africa to develop, implement and assess performance in a policy framework and indicators that provide for the full spectrum of different types of innovations and innovations activities.

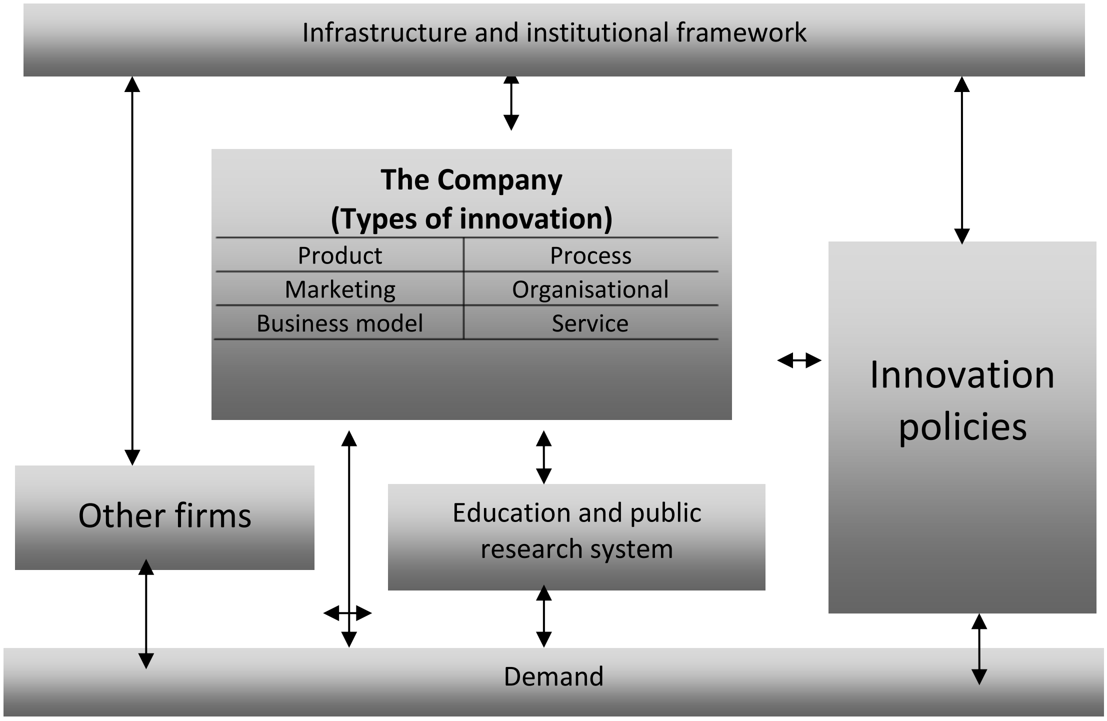


Figure 4.7.9-1: Innovation institutional framework
Source OECD (2009b:25)

4.7.10 Levels of Innovation

Innovation can be researched at three main levels, as shown in Figure 4.7.9-1. The macroeconomic level involves the study of aggregate economic behaviour of the economy as a whole (Schiller, 2009:21). The microeconomic level involves the study of individual behaviour in the economy and of the components of the larger economy (Schiller, 2009:21). The project level involves examining the management of innovation projects such as New Product Development (NDP) (Goffin & Mitchell 2009:23). Figure 4.7-7 views innovation as taking place within a system of interrelated components such as the political and social environment. The next section is a literature review on South Africa's current and evolution of innovation indicators for sustainable development through research in the NSI.

4.7.11 Innovation indicators

This section is a review of South African innovation indicators within the NSI. The scope of innovation should be broad beyond just measuring of traditional input and output indictors (Lundvall & Tomlinson, 2002; OECD, 2007b; Sutz, 2007:339). Innovation indicators can be used for measuring the strengths and weaknesses of the NSI, measuring progress made, tracking developments, evaluation and review of programmes (Chaturvedi & Srinivas, 2012:1641; Gaillard, 2010:79-89).

Some LDC such as South Africa have begun utilising the OECD's innovation survey manuals, which augurs well for basing debate on evidence. The innovation indicators can be prepared as part of policy learning that results from case studies findings and statistical indicators. For instance, phase one of the NSSD1 (2011-2014) involves undertaking an international benchmarking. The international benchmarking exercises against indicators such as the European Innovation Scoreboard (EIS) and the OECD Science, Technology and Industry Scoreboard can provide with a benchmark for South African NSI performance. Table 4.7.11-1 presents some reasons for innovation indicator benchmarking on various NSI elements.

Table 4.7.11-1: Suggested reasons for innovation indicator benchmarking on various elements

OBJECTIVES/VALUES	WITH BENCHMARKING	WITHOUT BENCHMARKING
Competitive and innovative	• Understanding of competitiveness • Established best practices • Strategic innovation	• Internally focused • Evolutionary change • Stagnant
Industry best practices	• Many options • Superior performance	• Few solutions • Frantic catch-up activity
People	• People centred • Valued organisational members • Source of strength • Lifelong learning	• Resource centred • Frantic, fire fighting • Autocratic leadership
Customer (students) requirements	• Valued internal and external customers • Rewards and recognition • Training and development	• Based on history or gut feeling
Partnerships	• Improved supplier performance • Procurement strategy • Collaboration and respect	• Perception and fear based
Establishing effective goals and objectives	• Credible, unarguable • proactive	• Lacking external focus • Reactive
Performance	• Value adding • True measures • Achieving targets • Best practices • Talent plans	• Pursuing pet projects • Strength and weakness not understood • Route of least resistance

Source: Oakland (2000:125)

Benchmarks can be used to analyse and improve the performance of public and quasi-public entities through the development of new indicators of efficiency, effectiveness, and productivity (Ammons, 1996; Niosi, 2002:299). However, the international indicators do not add much causal insight (Nilsson et al., 2008). As a consequence, it is proposed that LDC should engage with the process of designing domestic based indicators of data collection, rather than relying heavily on foreign developed indicators.

Sabatier (1993:10) and Nakamura (1987:4) state that "to understand a problem, one must acknowledge its value components". In South Africa, one of the major gaps in the NSI can be traced to the absence of responsibility for ensuring the collation, maintenance, analysis of both quantitative and qualitative components of the STI indicators. The major gaps include system, enterprise and sectoral level information and insights required for comprehending what underpins the NSI strength, weaknesses, and responsiveness or absence. According to this research, the STI indicators used serve in the NSI for planning and management and M&E.

4.7.12 Evolution of innovation indicators

Table 4.7.12-1 presents with a brief history of the evolution of the OECD innovation indicators and surveys.

Table 4.7.12-1: Short history of the development of innovation indicators

SHORT HISTORY OF THE DEVELOPMENT OF INNOVATION INDICATORS
1980s Nordic Council, United States (U.S.A) among others Experimental surveys. **1990s** Voorburg Group works on services statistics and innovation in services. UN City Group (www.voorburggroup.org). Work leading up to the first edition of the Oslo Manual (OECD, 1992) Product and process innovation in manufacturing. Work leading up to the first Community Innovation Survey (CIS) for reference year **1992**. CIS and CIS-like surveys are done repeatedly in many countries. **1995** – 1997 revision of the Oslo Manual leading to the second edition (OECD, 1997). The coverage of the manual was extended to include service industries. **1996** OECD Blue Sky Forum I Among other things, the forum introduced a systems approach to the understanding of innovation (OECD, 2001b) **2000s** **2000** Bogota Manual introduced by RICYT to deal with innovation in LDC in Latin America and the Caribbean. It covered manufacturing (RICYT/OEA/CYTED, 2001). **2002** – 2005 revision of the Oslo Manual leading to the third edition (OECD & Eurostat, 2005). The definition was expanded to add organisation change and business practices and market development. The systems approach was adopted and reflected in a Chapter on linkages. **2004** RICYT proposed an Annex to the Oslo Manual interpreting it for use in LDC. The United Nations

SHORT HISTORY OF THE DEVELOPMENT OF INNOVATION INDICATORS
Educational, Scientific and Cultural Organisation (UNESCO), Institute of Statistics (UIS) co-ordinates the preparation of the Annex which is added to the Oslo Manual in 2005.
2006 OECD Blue Sky forum II
Emphasise work on micro data, on analysis of outcomes and impacts as well as inputs, and on telling the story to the policy makers based on the analysis of innovation data (OECD, 2007a).
2007 AU/NEPAD adopt the Oslo and Frascati Manuals for use in surveys.
2007-2010 OECD Innovation Strategy, developed along with a measurement agenda (OECD, 2010b)
2010s
2010 RICYT begins revision of the Bogota Manual to include service industries and agriculture.
2010 NESTI starts the implementation of the measurement agenda (OECD, 2010b).
2010 On-going work on new areas: public sector, open, social and user innovation.

Source: OECD (2005b:16)

Table 4.7.12-1 describes and recognises innovation as a consequence of a systems approach. Input indicators in the EIS scoreboard include science and engineering (S&E) graduates, the population with tertiary education, broadband penetration rates, public and private R&D, innovation expenditures, ICT expenditures, early-stage venture capital, and SMEs innovation in-house and cooperating on innovation. Output-input indicators used are high-technology products, and EPO/USPTO/Triadic (US, EU, and Japanese) patents, trademarks and designs (OECD, 2007b:36).

The OECD and Eurostat (2005) Oslo Manual indicators of innovation activities include R&D performance, capital investment, IP protection, learning, education and design. The SA DST Ministerial Review Committee (2012:84) criticises the current mode of innovation indicator by stating that “merely listing GERO, BERD, PhDs per million of population, Institute for Scientific Information (ISI) counts and United States Patent and Trademark Office (USPTO) patents tells but one part of the story”. Having examined the innovation indicators, the next section undertakes a review of triple helix model in South African context.

4.8 TRIPLE HELIX MODEL

This research section makes use of a tripartite model that reviews literature on the structure of the three main actors and responsiveness of the South African NSI. A quadruple helix formation occurs when the civil society becomes directly involved, which is not the case in this research. The benefits of triple helix interaction in this research context are many, as the model allows for combinatory innovations to take place among the three interdependent main actors and the reorganisation of the spiral as the South African NSI evolves.

Leydesdorff and Etzkowit (1996) introduced the triple helix model at an academic conference to illustrate an alternative perspective on the dynamics of innovation. The triple helix was derived from a need to extend the traditional linear views and neo-classical economics (Leydesdorff & Etzkowitz, 1996). A helix is characterised by a spiral form, such as the double helix shape of DNA molecules (Etzkowitz et al., 2007). Triple Helix is thereto employed as a policy tool to promote innovation (Nuur, 2005; Lavén, 2008; Lindberg, 2011). Leydesdorff and Etzkowitz (1996) used the helix metaphor to demonstrate a triple spiral, policy network where industry, academia and state interact in an evolutionary fashion, allowing for new innovative re-combinations. The Triple Helix model of university-industry-government framework provides the research with an avenue for exploring SD in South Africa through research in the NSI. The inclusion of the South African civil society into the Triple Helix model results in the quadruple helix model.

Etzkowitz et al. (2007) presented a typology of innovation systems which entails three evolving perspectives. First, is the Triple Helix I, a static triple helix in which the government encompasses academia and industry and directs the relations between the two actors. Second is the Triple Helix II, a *laissez- faire* triple helix, consisting of separate institutional spheres, where government, university and industry operate separate from each other. In Triple Helix II model, the university provides basic research and trained persons. The third, Triple Helix III is an interactive model, which consists of overlapping, yet relatively independent, institutional spheres. In Triple Helix III model, the university plays a significant role in the NSI (Etzkowitz et al., 2007; Lundvall, 2007). This research focuses on the Triple Helix III model as an important model for reviewing the South African NSI. The role of HEIs in this configuration can be referred to as the ‘third mission’ (Etzkowitz et al., 2007). Making a contribution to economic growth is becoming a central task next to teaching and research, namely ‘entrepreneurial science’ (Etzkowitz et al., 2007).

Within the triple helix model, a major policy weakness in South Africa lies in the inability to place the private sector at the centre of the innovation process nearly five years after the OECD review (Bell & Pavitt, 1993; OECD, 2007b; SA DST Ministerial Review Committee, 2012:14). This research echoes similar words with scholars such as Bell (2007:67); Wamae (2009:216); OECD (2007b); SA DST Ministerial Review Committee (2012:14) unless the lacuna is addressed not only in the design of innovation policy documents, but also in the policy implementation, it is unlikely that the private sector will effectively invest in research commercialisation (Bell, 2007:67; Wamae, 2009:216). The deficiency constitutes a major drawback to knowledge creation and commercialisation.

4.8.1 The South African Government Role in the NSI

This section is a review on the role of government and governance framework required for South Africa's NSI optimal functioning. This research shares similar views with the SA DST Ministerial Review Committee (2012:104-114) on some of the responsibilities of the South African government and governance, which include: (i) setting up the NSI vision through a comprehensive policy landscape; (ii) providing with an enabling set of framework conditions on agreed mechanisms for prioritisation and agenda setting; (iii) coordination mechanisms and direct participation; (iv) providing infrastructure as services and utilities, promoting human resource development and mobility; (v) provision of knowledge infrastructure and mechanisms to promote knowledge transfer and exchange, Including dissemination, networking and internationalisation; (vi) acts as 'business' innovator through state-owned enterprises, and research performer through science councils and; (vii) mechanisms for knowledge transfer and dissemination, including protection IP rights and provision of direct and indirect incentive schemes; (viii) ensuring an enabling environment for innovation of appropriate policy and regulations; and (ix) exercise of oversight, and the accountability of those entrusted with implementation; and policy learning, resting upon monitoring, measurement and evaluation for review.

It may be argued that achieving the aforementioned responsibilities will require the South African government to put in place a developmentalist ideology focusing on industrialisation, economic growth and expansion of human capabilities. In the research context, South African government is viewed as the required 'system integrators' a term coined by Revi (2007) to refer to the ability to implement multi-faceted policies projects and coordinate grant support. However South African departments involved in development activity and service delivery are presently poor initiators and supporters of innovation (SA DST Ministerial Review Committee, 2012:183).

The NGP (EDD, 2010:28) recognises the role of an effective, developmental state and raises at least three critical institutional issues, namely: (i) the role of the state (South African government); (ii) the South African market and key market players' and (iii) and social mobilisation and dialogue in dealing with the sluggish economic growth, poverty and joblessness. The developmental state agenda notwithstanding, the NGP document (EDD, 2010) is content in nature, with the exception of repeating the 2008 TYIP indicators, discussing little about innovation, R&D and technology. The NGP content nature is insufficient for creating a developmental state for positioning South Africa outside mainstream thought on the importance of innovation. In order for SST to take place in the LDC, the state has to take on a developmental role as well as a broader SD role (Koppenjan & Klijn, 2004; UNCTAD, 2012:82). Incorporating SST policies into the central element of national development strategies, is one way that the government can adopt a developmental role (Ocampo, 2011:11). Table 4.8.1-1 presents a summary and examples of government roles and expected actions for the NSI functioning. In this context, the government should be concerned with both the process and the substance of enhancing the NSI.

Table 4.8.1-1: Summary and of government role within the NSI

INSTRUMENT	ROLE OF STATE	FUNCTIONING
Public demand		
General procurement	Buy and use	State actors consider innovation in general procurement as main criterion in tenders.
Strategic procurement (technology-specific)	Buy and use	State actors demand an already existing innovation in order to accelerate the market introduction and the diffusion.
Co-operative procurement	Buy/use moderation	State actors are part of a group of demanders and organise the coordination of the procurement and the specifications.
Direct support for private demand		
Demand subsidies	Co-financing	The purchase of innovative technologies by private or industrial demanders is directly subsidized.
Tax incentives	Co-financing	Amortisation possibilities for certain innovative technologies.
Indirect support for private and public demand: information and enabling (soft steering)		
Awareness building measures	Informing	State actors start information campaigns, advertises new solutions, conducts demonstration projects (or supports them)
Voluntary labels or campaigns	Supporting Informing	The state supports a co-ordinated private marketing activity which signals performance and safety features.
Training and further education	Enabling	Private consumers or industrial actors are made aware of innovations and simultaneously use them.
Articulation and foresight	Organising discourse	Societal groups' signals as to future preferences (and fears) are articulated and signalled (including demand foresight).
Regulation of demand or of the interface demander – producer		
Regulation of product performance and manufacturing	Regulating, controlling ("command and control")	The state sets norms for the production of innovations (market approval, recycling requirements, regulation
Regulation of product Information and norms		The state creates legal security by setting up clear rules on the use of innovations (for example electronic signatures).
Support of innovation regulation activities	Moderating	The state stimulates self-regulation (norms, standards) of firms and plays a role as catalyst by using standards.
Standards to create a market	Moderating, organising	State action creates markets for the use of technologies or sets market conditions for demand innovations.
Systemic Approaches		
Integrated demand measures	Combination of roles	Strategically co-ordinated measures which combine various demand side instruments.
Integration of demand and supply-side measures	Combination of roles	Combination of supply-side instruments and demand-side impulses for selected technologies or services.

Source: Adapted from Edler (2009:11-12)

Table 4.8.1-1 is not intended to be viewed as a complete list, but a way to analytically capture the activities and learning processes at hand, allowing for overlaps between the key functions. In this research context, the South African government role is to 'influence on direction of search' (Hillman et al., 2011:405), as a mechanism of steering the NSI pathway. Providing 'positive externalities' such as pooled labour, knowledge spill-overs, specialised intermediate goods, and complementary products, services and infrastructure (Hillman et al., 2011:405) is another important role required of the government to further push adoption of commercialised research. The 'entrepreneurial experimentation' (Hillman et al., 2011:405) role will require the application of many and varied experiments, for example in STI, design and marketing performed in an entrepreneurial manner. The government can also take responsibility of 'market formation' (Hillman et al., 2011:406) in articulating both domestic and international demand, formulating standards and resolving uncertainties. The government role of 'legitimation' implies social acceptance and compliance with relevant institutions, which is crucial for the system growth (Hillman et al., 2011:406). The government can create legitimacy by harnessing national development projects and by taking on a leadership role that engages in a relative decoupling (UNCTAD, 2012:83). The government can also play a crucial role towards bridging the technology gap (Singer, Cooper, Desai & Freeman, 1970; Furman, Porter & Stern, 2002: 900-930).

The aforementioned government's role should not be static, but evolve within different phases of research commercialisation and innovation process. During the "learning curve" that is the innovation take-off phase (Neij, Andersen, Hoppe-Kilpper & Morthorst, 2003:16), the government can contribute to 'resource mobilisation' (Hillman et al., 2011:405), by providing funds, incentives human resources skills and R&D investments that are time bound. During the "acceleration phase" (Neij et al., 2003:17), the government plays the role of innovation stimulation and learning. The government's role shifts to one of innovation controller and consolidator during the "stabilisation phase" (Neij et al., 2003:18).

According to the White Paper (DST, 1996:20) the government's three key roles in the NSI, can be thought of as: (i) ensuring that South Africa has in place a set of institutions, organisations and policies which give effect to the various functions of NSI; (ii) ensuring that there is a constructive set of interactions among those institutions, organisations and policies; and (iii) ensuring that there is in place an agreed upon set of goals and objectives which are consonant with an articulated NSI vision of the future which is being sought. In this way, the government can also play an important role of an enabler of SD (economic, social and environmental) and research in South Africa through the selection and implementation of appropriate integrated policies and fostering linkages within the NSI.

The DST/HSRC (2011:2) states that "it is more important for government to create an enabling environment for innovation" than to work only through funding programmes. Therefore, apart from funding the NSI, the government can play the role of an enabler of SD (economic, social and environmental) and research in South Africa. This role can be achieved through the selection and implementation of appropriate integrated policy instruments and visions (short-, medium- and long-term) as an intrinsic component of South Africa's development strategy.

Since the 1996 White and Green Papers, the South African government has made considerable effort to develop new policy instruments and to improve existing ones in important ways that fit national objectives and improve intended impact. Nevertheless, within the NSI the government can further make use of public policy instruments in promoting SD, resource decoupling and innovation policy. Market-based and economic category, such as fiscal-based and trade policy-based is one type of public policy instrument that that can be used to promote SD, resource decoupling and innovation policy (UNCTAD, 2012:84). Another public policy instrument is market mechanisms, which include competitive research funding, subsidies and investment support, green public procurement environmental taxes, marketable certificates to subsidies and environmental fees (Lafferty et al., 2005:260). Regulatory, command and control is another policy instrument category that can be used to legally enforce norms and standards. This policy instrument includes environmental liability, regulation of IP right, competition (anti-trust), environmental control and enforcement.

Information measures is policy instrument category that can be used to promote environmental quality by encouraging changes in consumer and producer behaviour, such as triple-bottom line sustainability reporting (Elkington, 1994), eco-labelling, consumer advice services, information centres, incorporating environmental quality targets and environmental monitoring (UNCTAD, 2012:84-86). Education and research is policy instrument that can be used to promote public education and training, as well as R&D focused on resource and environmental efficiency. Soft instruments can also be used as voluntary means for advocating certain norms rather than the use of coercion or economic incentives (Borrás, 2009:7). The use of cognitive mechanisms as public policy instruments can be applied in problem 'framing' (Fischer & Forrester, 1993). The Cognitive mechanisms can be represented in policies such as R&D support, technology foresight activities, and network building such as private–public partnerships (Hillman et al., 2011:409). Metainstruments can be used in providing intelligence to policy design, for example innovation indicators, policy benchmarks and technology foresight (Borrás, 2009:7). normative mechanisms as a public policy instrument concerns the development of values and beliefs about 'what is good' ('logic of appropriateness'), as well as official strategies, visions and goals, which signal to actors what society 'wants' (Hillman et al., 2011:409).

The aforementioned policy instruments provide with important literature for defining crucial normative issues for South African government policy-makers within the NSI. The South African government provides through public research institutes (PRIs) significant component of the public sector R&D and technology transfer services that have direct industrial applications. Within the founding law, a functional area of the research institutes in the public sector is to carry out research (Botes et al., 1992:288). The PRIs undertakes applied research, which carries some practical value (NACI, 2010). Depending on the particular kind of activities being undertaken, research institutes determine own research procedures (Botes et al., 1992:288-293). There are currently 12 major PRIs, which are exclusively R&D performing institutions, with the exception of the MRC which also has an agency function. In principle, the funding of the PRIs' consists of a parliamentary component (on average 50% of the total budget of the institution) and income generated through contract activities, which account for the rest of the budgets. The DST/HSRC (2013) national survey shows that in-house R&D expenditure by the science councils accounted for 16.5% of GERD in 2009/10, an increase from 14.9% in 2008/09. According to National Treasury (2006:12-19), at institutional level each PRI is required to submit to the relevant department (and Minister) a detailed motivation and budget for the next year, based on the PRI's strategic plan and report on key performance indicators for the previous year and business plan for the next year.

Improving energy efficiency at a national level is one the strategic policies being undertaken by a South African PRI. The policy is called adoption of an Energy Efficiency Strategy in South Africa. The Energy Efficiency Strategy was published in 2005 and reviewed in 2008 and sets a national long-term target for energy efficiency improvement of 12 per cent by 2015. The Strategy states that energy efficiency improvements will be achieved largely via enabling instruments and interventions, which will include *inter alia* efficiency labels and performance standards, energy management activities, energy audits, economic and legislative means, as well as the promotion of efficient practices.

4.8.2 Defining Governance

Pierre and Peters (2006:24) note that "governance can be composed of four types of procedures; objective setting, decision-making, coherence and steering". "Governance is about the handling of complexity and the management of dynamic flows. It is fundamentally about interdependence, linkages, networks, partnerships, co-evolution and mutual adjustment" (Mothe, 2001:21). This research adopts the definition of governance according to the World Bank Worldwide Governance Indicators Framework WGI (2013:1):

> "Governance consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them"

An important conceptual change within public administration has been the shift from 'government to governance' (Kickert, Klinjn & Koppenjan 1997; Rhodes, 1997; Rhodes, 2007; Van Kersbergen & Van Waarden, 2004; Frederickson, 2005). Policy integration problems are problems of co-ordination in the governance structure that reveal systemic failures (Lafferty et al., 2005:255).

4.8.3 Horizontal and Vertical NSI Governance

Governance has also been viewed in literature as an alternative from the traditional hierarchical government to a horizontal network relationship and interactions that shape decision-making (Kohler-Koch & Eisling, 1999; Pierre & Peters, 2005; Lundqvist, 2001:231; Hillman et al., 2011). In this context, the traditional government mechanisms are not excluded because, in principle there are reasons to blend into 'hybrid arrangements' (Hey, Jacob & Volkery, 2007) in shaping SD based on commercialisation of research in the NSI. Both the contemporary and traditional governance trends are evident in the field of innovation (Kaiser & Prange, 2004:256).

The concept of governance is pluricentric rather than adherence to unicentric systems, which has been used in this research context to refer to the actions of a wide variety of public, private and semi-public actors (Kemp, Parto & Gibson, 2005:26; Bekkers et al., 2011a:8). It may be presumed that the NSI actors are able and willing to define existing governance interdependency. Furthermore, the processes of governing involve negotiation, concentration and cooperation rather than coercion, command and control (Van Kersbergen & Van Waarden, 2004:152; Bekkers et al. 2011b:11). For instance, negotiation is a field of knowledge and endeavour that focuses on gaining the favour of people from whom we want things (Cohen, 1980:5; Meredith & Mantel, 2010:164).

Some literature claims that improvements in public administration cause higher subsequent growth, which firstly are based on dubious measures of administrative performance, and secondly do not provide with the direction of causality (Kurtz & Schrank, 2007:22-31). Even using the dubious measures, Kurtz and Schrank (2007) indicate that the causality is more from growth to improvements in governance than from improvements in governance to growth. For example, Wade (2010:155) states that improvements in the U.S.A governance occurred after and not before economic growth.

Kaufman, Kraay and Mastruzzi (2005:93) observe that the World Bank uses 'absence of red tape' as one of the main criteria of 'the quality of bureaucracy' and governance, which is measured by how quickly decisions are made in regulatory agencies and how easily 'foreign investors can go about undertaking own business'. South Korea and Taiwan of the 1950s to the 1980s would score quite low on administrative capacity, where the two countries applied delays as 'tactical' in pursuit of industrial policy objectives (Wade, 2004b:6). Without the 'interference' of the state the FDI subsidiary would have been less likely to switch suppliers from foreign to domestic (Wade, 2010:155).

The following five governance conditions may be identified as applicable in South Africa. First is the strategic innovation policy condition, which is a crucial tool for aligning the network actors' expectations within the system for effective governance of the NSI (Nilsson et al., 2008; Borrás, 2009; Bekkers et al., 2011b). The existence of positive administrative policy coordination, in terms of horizontal coordination and vertical coordination is a second condition for effective governance. The presence of a balance between diversity creation that enhance governmental action and the market selection in the NSI is a third condition for effective governance.

Policy learning, as a reflexive process through which public actors take stock of policy initiatives is a fourth critical condition for effective governance (OECD, 2005b:22; Borrás, 2009:14; Kahn, 2008:164). A fifth condition for effective governance is the public legitimacy of innovation policy, which depends on the actual political policy-making (Van Asselt & Vos, 2008:286; Borrás, 2009:14).

The primary function of Multiple Governance Framework (MGF) provides a conceptual (meta-) basis for contextual theory building in the study of the NSI governance and policy making process indicated in Table 4.8.3-1.

Table 4.8.3-1: Multiple governance framework approach for public policy

SCALE OF ACTION SITUATIONS	CONSTRUCTIVE GOVERNANCE	DIRECTIVE GOVERNANCE	OPERATIONAL GOVERNANCE
System	Institutional design	General rule setting	Managing trajectories
Organisation	Designing contextual relations	Context maintenance	Managing relations
Individual	Developing profession norms	Situation bound rule application	Managing contact

Source: Hupe and Hill (2006:23)

The MGF shown in Table 4.8.3-1 has a multidimensional as well as a nested character, which consists of governance, actors, actions, action levels, action situations and administrative layers (Hupe & Hill, 2006:26).

4.8.4 Governance Theories

A number of different theoretical frameworks have evolved that can be used to explain and analyse governance and the government. These frameworks can be borrowed from different disciplines with different perspectives and terminologies. The agency theory paradigm arises from the field of finance and economics, transaction theory arises from economics and organisational theory, while stakeholder theory and steward theory arise from a more social-oriented perspective on corporate governance (Solomon & Solomon, 2008:36). The aforementioned three theories support the need for stricter governance principles and the frameworks generally overlap theoretically.

4.8.5 The Agency Theory

The agency theory views the government as the agent and the other network actors as the principal within the NSI. Archer (1995:246) argues that "…neither the structuring of society, nor the social interaction responsible for it can be discussed in isolation from one another". Archer (1995:247) therefore, proposes a 'double morphogenesis' that involves both the re-structuring (change processes) and the agency. In this research context, examining the interplay between the NSI governance structure and agency theory will provide an in-depth research comprehension.

The agency theory is mainly concerned with resolving two problems that can occur between the agent and the other actors' relationship. The first problem arises when the objectives of the principal and agent conflict and it is difficult or expensive for the principal to verify the agent's behaviour. The second problem is the risk-sharing problem that arises when the principal and the agent may prefer different actions because of different risk preferences (Luo, 2008:2-3). The principals are therefore worried about agents' opportunism and self-seeking with guile. The government is likely to display a tendency towards 'egoism' that is, behaviour that leads to maximising one's own perceived self-interest (Boatright, 1999). As a result, it is important that the NSI actors 'monitor' the government policies and help to resolve agency conflicts. Overall, a well-designed governance system is necessary to the point that the system effectively guides and monitors the government behaviours while not hindering government's flexibility and aspiration to make decisions that are in the best interest of the NSI system. Put simply Luo (2008:3-4) states that the agents should avoid a situation of 'the best-governed and worst-managed'.

4.8.6 The Stewardship Theory

The stewardship has been supported by agency theory critics, who contend that the theory is based on a false premise on the nature of man. The stewardship theory holds that there is no conflict of interest between steward and principals (Davis, Schoorman, & Donaldson, 1997). The steward seeks to attain the objectives of the institution. Therefore, even where the interests of the steward and the principal are not aligned, the steward places higher value on cooperation than defection (terms found in game theory). In this research context, the stewardship theory focus on governance structures that facilitate and empower the NSI stewards rather than the use of monitoring and controlling tools. However, Solomon & Solomon (2008:34) state that "implementing stewardship governance mechanisms for an agent would be analogous to turning the hen house over to the fox". As a result, agency prescriptions can be viewed as the necessary costs of insuring principal utility against the risks of the government opportunism.

4.8.7 The Stakeholder Theory

The stakeholder theory has developed gradually since the 1970, with a historical lineage, practical applications and intellectual appeal more substantial than agency theory, and yet has had much less impact on thinking and governance policy (Donaldson & Preston, 1995:65). The stakeholder theory defines organisations as multilateral agreements between the enterprise and its multiple stakeholders (Freeman, 1984; Clarke, 2004). The stakeholder approach focuses on the 'entire network of formal and informal relations that determine how control is exercised within the NSI.

Wijnberg (2000:332) makes a number of stakeholder theory recommendations, which when applied in this research will require, firstly, that the NSI structure to permit sufficient autonomy for the research institutes to confront ethical dilemmas. Second, the codes of conduct or mission statements should be fruitfully used to enforce or encourage virtuous decision-making.

Pieterse (2010:11) points out that different stakeholder have different takes on the meaning of and how to achieve (sustainable) development. Gray, Owen and Adams (1996:45) view a stakeholder as any group or individual that can be influenced by, or can itself influence, the activities of the organisation. Starik (1994) offers a narrow definition of stakeholders as "individuals or groups with which the 'government' interacts who have a 'stake', or vested interest…' on the broadest end of the spectrum, Starik (1994:94) further suggests that the stakeholder is "any naturally occurring entity which affects or is affected by 'the institutions' performance". Stakeholders' definitions may be distinguished as illustrated in Figure 4.8.7-1 along the strategic, versus a normative dimension.

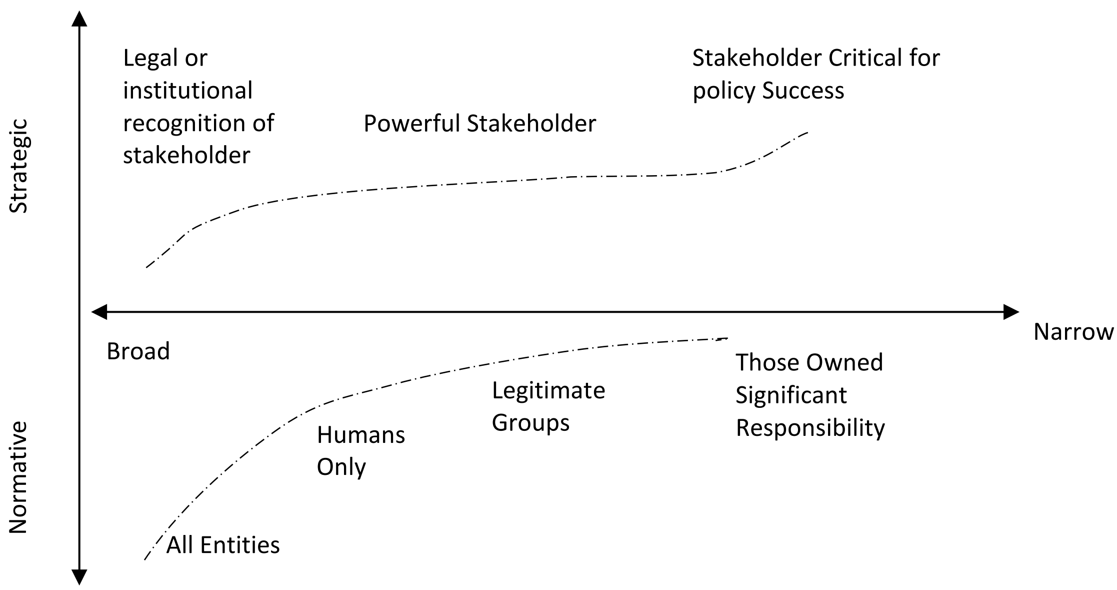


Figure 4.8.7-1: Strategic and normative dimensions of stakeholder definitions
Source: adopted from Friedman and Miles (2006:12)

Figure 4.8.7-1 illustrates that strategic dimension fall under a continuum that has varying degrees of impact on the existence of the institution, while along the normative dimension are definitions of stakeholders that differ in scope to reflect societal norms. Normative refers to the way people live in an ideal 'good' society; and what people ought to do, in order to achieve a 'good' society or any notion of the 'good' (Friedman & Miles, 2006:34). In the part communication, related to sustainability works, norms created in the life-world and brought into the professional atmosphere play a crucial role (Wickenberg, 2006:114). Given the number of contractual relations that exist in among the NSI actors, both explicit and implicit, Dunn (1996:144) proposes that 'institutions' should care enough for the least advantaged stakeholders not to be harmed and privilege those stakeholders with whom the ‘institutions’ have a close relationship.

Carroll (1999:270-272;2004:115-117) suggests that stakeholder identification and analysis should be approached by finding answers to questions such as: Who are the stakeholders? What are their interests or claims? What opportunities and threats do they present? What responsibility does the corporation have to each group, whether economic, legal, ethical or philanthropic? What strategy is best designed to accommodate or cope with these challenges or opportunities? What response should be made: accommodating, negotiating, manipulating, resistance or a combination? (Carroll, 1999:2004).

The NSI actors include the government and the public authorities. Sometimes trade unions play marginal role in the NSI. Both the academic and the business sector can have an *ex officio* presence in all the NSI matters. The implementation of New Zealand's Growth and Innovation Framework (GIF) required widespread stakeholder involvement and commitment across the public and private sectors (OECD, 2005d:50), which can be emulated in the South African NSI context.

4.8.8 Governance in South Africa

In this study context, SD in South Africa, resulting from commercialisation of research in the NSI takes place within a system of governance. A governance arrangement influences the NSI functionality and places the principal responsibility of the NSI on the government.

In the governance context, according to this research, the first responsibility of the South African government is that of setting out the role of the DST in relation to the rest of government departments within the NSI. The second responsibility is that of setting the role and positioning of the HEIs and training, the science councils, NACI, TIA and the need for establishing new state agencies. The third responsibility is that of optimising the role of the major non-state actors (private sector, civil society and community-level groups) within the NSI. Some of the dramatic improvements in the public service deliveries in South Africa include the ease with each passport and ID book is being issued and renewed, the massive transformation of the tax-collection system introduced by e-filing and a much-simplified online employer and worker registrations and payments by the unemployment Insurance Fund (SA DST Ministerial Review Committee, 2012:83). Figure 4.8.8-1 illustrates key governance processes framework, which consists of a set of variables as connected through a number of feedback loops.

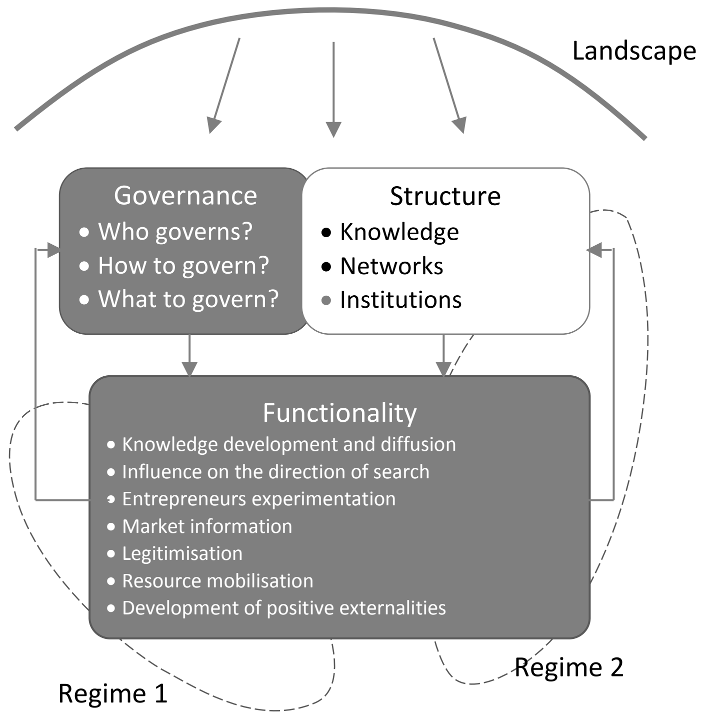


Figure 4.8.8-1: Schematic presentation of theoretical framework

Source: Hillman, Nilsson, Rickne & Magnusson, 2011:411)

The procedure for using Figure 4.8.8-1 entails defining NSI in focus and identifying structural elements such as research and knowledge, networks actors, institutions, landscape factors and relevant regimes.

Governance is a concept that was first widely explored and embraced in the late 1980's. Governance of both the South African NSI and related policies can be categorised into three distinct periods (Tsipouri & Papadakou, 2005:18). First was the birth of the NSI up to 1985, which was characterised by a central agency for funding R&D, mainly academic research capabilities. Second was the uncoordinated growth phase, which took place between 1985 and 1999, where innovation represented a "shopping list" rather than a consistent policy. In this phase agencies continued to shift within government departments, funds were increased substantially, R&D content expanded to include more missions, and new actors were incorporated. Financial co-ordination is the third and current phase, which took place from 2000 onwards. In this phase government ministries and secretariats have continued to recognise and incorporate innovation into policy agenda with the establishment of a special financial mechanism. The challenge of the 21 century era however is that of real co-ordination of the South African NSI with an emphasis on vision, agenda setting and priority settings.

It is suggested that the South African government can exert a strong support for innovation through procurement. The PMI (2008:156). describes procurement as:

> The process of acquiring new services or products, which covers the financial appraisal of the options available, development of the procurement or acquisition of suppliers, pricing, purchasing, and administration of contracts. It may also extend to storage, logistics, inspection, expediting, transportation, and handling of materials and supplies.

This research supports the view that procurement can be used at a tool for wider social and economic goals, including innovation (Nissen, 2004:643-645; Breznitz et al., (2011:92; Lember et al., 2014:89). Further, Breznitz et al. (2011:92) states that "public procurement is an established policy tool …the new challenge is the idea of generating demand for innovation". Through procurement, the South African government and public agencies can support innovations by creating the demand pull for products and services (European Commission Working Group, 2006). Procurement can also be used in providing a 'lead market' and market initiation for new technologies (Edler & Georghiou, 2007; Lember et al., 2014:87). Government procurement can be used to provide a testing ground for new innovations in order to mitigate risks (Rothwell, 1992). Market consolidation, through bundled demand, leading to harmonisation of fragmented markets, is another procurement strategy that can be applied by government (Edler & Georghiou, 2007). The government can also bear entry costs, creates critical mass, and signal the market and link innovation to production ((Markides & Geroski, 2005; Edler 2009:8; Lember et al., 2014:87-88).

4.8.9 The Private Sector

This section presents a literature review on South Africa's private sector in terms of the provision of an enabling environment for innovation in the private sector and social spheres, through appropriate policy and regulations and the promotion of knowledge transfer and exchange. The section discusses South Africa's private sector performance in terms of research, SD and innovation-related activities. Collaboration of the HEIs with industry is regarded as highly desirable for research commercialisation. It is observed that there is a gap in South African research commercialisation. The SA DST Ministerial Review Committee (2012:83) observes that

> It is clear, however, that the way in which knowledge spill-overs have operated historically, and how they operate now, are unknown. Although government wishes to see the commercialisation of publicly funded R&D through its transfer to companies, mechanisms to this end, that are contextually sensitive, do not exist in South Africa. In less formal ways, however, there is a steady flow of ideas and people

out of large firms, who then create start-ups at localities such as the Innovation Hub. Much more information is needed to understand the trajectory of such entrepreneurs.

The private sector is made up of local businesses, including SMEs and large enterprises, foreign-owned and foreign R&D-intensive companies in South Africa. A clear focus in public policy on business as the largest NSI actor is still absent nearly five years after the OECD review. The SA DST Ministerial Review Committee, (2012:82) notes that:

> "… Is probably the biggest 'silence' in South Africa's policy and institutional architecture: the nexus between the key knowledge-intensive social actors, one of the most powerful being the private sector. The role of the private sector, and its relationships with other sectors (especially government, higher education and civil society), will be fundamental to the strength of the NSI in the future" (SA DST Ministerial Review Committee, 2012:82).

South Africa has experienced a paradox of a strong track record in industrial innovation and a relatively stagnant economic performance. The paradox according to the NSI Country Review report by the OECD (2007b) has been neglected and should be confronted in achieving South Africa's future NSI objectives. The OECD (2007b:11) states that "mental models of how the innovation system operates overly focused on the role of the state". The OECD (2007b:11) recommended a revised NSI mental model that places the private sector at the centre/heart of the NSI (OECD 2007b:11; Kokko, 2010:126). The private sector should be located within the centre of the NSI because the sector is affected, directly or indirectly, by the enabling or framework conditions that prevail in the broader environment (SA DST Ministerial Review Committee, 2012:110). However, despite contrary evidence from the three South Africa's National R&D Surveys undertaken every four years since 2002, the DST steadfastly maintains that the private sector is failing to join government in supporting national objectives and thereby justifying its own activist approach. Kahn (2011) also notes that the business appears to have an equal misunderstanding, if not mistrust, of the government's role.

Another paradox of the South African companies is that of 'innovating' but no patenting and not translating into new jobs (SA DST Ministerial Review Committee, 2012:125). The paradox can be attributed to the types of innovations that were introduced during the CIS 2009/10 survey, which were mainly incremental and adaptive. Segal (2011) provides a case study on the generation of IP by examining 'dry cooling' power station technology in which Eskom is a world leader, but did not patent to protect the IP. Segal (2011:9) notes that "it is not in the culture of the electricity supply industry, perhaps particularly in the power utilities themselves, to think proactively and certainly protectively about management of its IP. This attitude is inevitably reinforced by the fact of so many utilities internationally being publicly owned monopolies that typically do not compete with one another”.

The business sector is a major performer and funder of R&D in South Africa (OECD, 2008:152). In particular, the services sector has been the main engine of growth in the most recent period with a strong record of success in innovation, especially in areas of information technology (IT) applications, and strong R&D performance (OECD, 2007b:12). South Africa strong in pharmaceuticals companies such as Aspen, Adcock-Ingram and Cipla, but is currently not involved in drug discovery. The South African private sector has also undertaken considerable learning, in terms of absorptive capacity. The inclusion of the Universities of Cape Town, the Witwatersrand and KwaZulu-Natal in the international league tables is due to the local and global private sector high regard for the leading research universities. Excluding foreign funding, the South African private sector funding of local research in the universities was among the highest in the world at 10.8% in 2012, an amount of R454 millions. In this research context, the presence of strong connections between the public research sector and local industry is critical for research commercialisation. For that reason, private sector research absorptive capacity is important for strengthening South African NSI. Notably, List (1841/1959/1904:162) cited in Freeman (2002:193) recognises that industry (business sector) should be linked to the formal institutions of science and education.

The South African government policy is concerned with developing the NSI, which is strongly focused on domestic R&D activities and domestic sources of innovation. The domestic focused approaches to supporting the NSI development leaves a large gap in terms of exploiting imported technology inward FDI. A lot of NSI restructuring is required for South Africa to attract R&D related FDI. The SA DST TYIP (2008:15) intends to “increase foreign investment in South African health-related R&D (excluding clinical trials)…” This statement indicates that the TYIP intends to restrict foreign-funded clinical trials, a critical strength of South Africa’s health sciences that has ethically sound and scientifically robust clinical trials conducted by foreign-funded scientists in South Africa's HEIs. ‘The Farmer to Pharma’ is the first of the SA DST TYIP (2008:12-14) ‘Grand Challenges’, which showcases however the next decade South Africa must work to become a world leader in biotechnology. However, the grand challenge does not make reference to expected contribution of the private sector agribusiness and pharmaceuticals in the value chain. The second of the SA DST TYIP (2008:12-14) ‘Grand Challenges’ is the ‘Space S&T’, which also does not connect both the satellite construction and the development of launch capacity with the defence and aerospace industry, especially the telemetry components. The third of DST's TYIP (2008) Grand Challenges is the 'Energy security'. The minerals-energy complex relationship in South Africa has generated a large support services industry, which includes equipment manufacturers and providers of scientific and technical services (including design, software, engineering, modelling, hydrological and geological). Although much of the highly-focused funding by government to the business sector has been terminated (such as Eskom, Atomic Energy Corporation and Sasol, defence/Armscor and mining), on-going support for business R&D remains high on the policy agenda, which is supported by a HEIs policy, the White Paper on S&T and NRDS that emphasise the strategic position and encourages cooperation as a link between research and business.

The knowledge transfer that takes place among the NSI actors is vital in shaping the direction and extent of innovation (Arnold & Bell, 2001:285; Bell, 2007:72). In this research context, knowledge and technology transfer is a process by which existing technology is transferred or transformed into useful processes, products and programs to fulfil the user's needs (Hodgkings, 1989; Krull, 1990). It may be viewed that the capacity for novelty, learning and adaptation as resting on the free flow of knowledge within and across organisations and national systems. A common feature of acquisition of technology-importing investment projects foreign technology, is the "Investing in engineering capabilities: Petroquisa's Copesul project in Brazil" (Sercovitch, 1980), which has required the Brazilian government support for the enterprises (not necessarily funding) to make the necessary investments; government-backed development banks. South Africa does not have such initiatives in place, creating the impression of lack of support by government or by the national development bank (OECD 2007b:177). Hausmann and Klinger (2006:7) argue that for "South Africa to grow, it must export" and conclude that "a lagging process of structural transformation is part of the explanation for stagnant exports per capita. Slow structural transformation is found to be a consequence of the peripheral nature of South Africa's productive capabilities".

It is important that the role played by the three main sets of government instruments available for supporting business R&D should be examined. The first of the three instruments is the direct support of R&D projects, such as the IF, the THRIP and the BRIC. The second is the funding for technology transfer and similar initiatives such as the Godisa and Tshumisano trusts. The third is the indirect support through tax rebates. However, the SA DST Ministerial Review Committee (2012:14-17) notes that the tax benefit for business R&D activity that meets set criteria is being taken up rather slowly. During data analysis, secondary data on the South African private sector will be utilised, mainly from the latest South African CIS National Survey of Research and

Experimental Development Main Results of 2009-2010 by the (DST/HSRC, 2013) and the FTSE Top 500 of 2012/2013. To date, six CIS surveys have been carried out, with a sixth conducted in 2009. South Africa has also so far undertaken three national innovation surveys based on the OECD's 2002 Frascati and 2005 Oslo Manuals. There is no 'one-size-fits-all' approach in knowledge and technological learning. As such, the Technopolis Group (2008:2) has developed a schema (Figure 4.8.9-1) that assists in the varying needs and capacities of enterprises according to capability of R&D and technological (Technopolis Group, 2008).

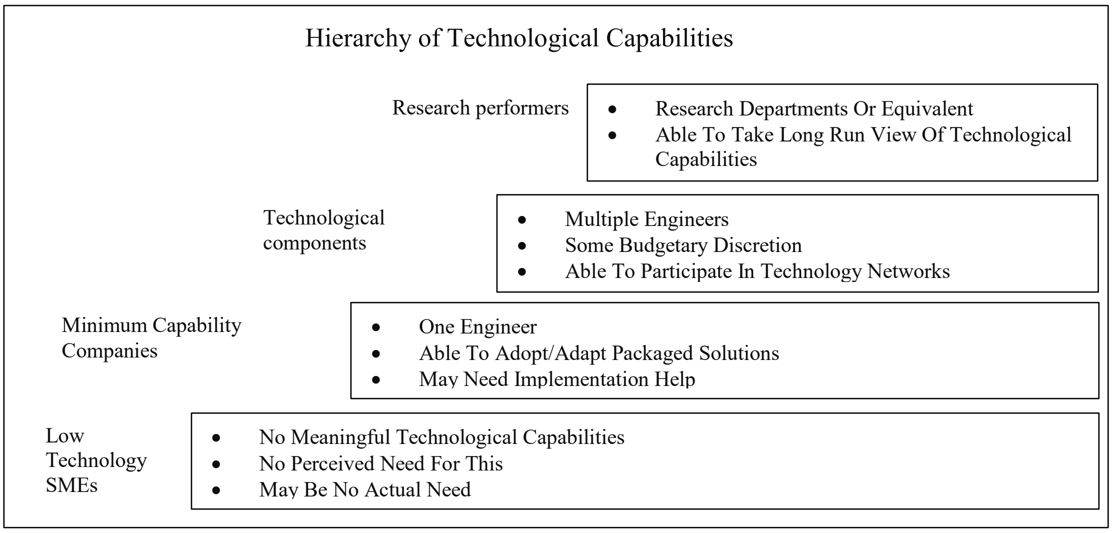


Figure 4.8.9-1: Enterprises characteristics and technological capabilities for R&D
Source: Adopted from Technopolis Group (2008:2)

Essentially, Figure 4.8.9-1 illustrates a hierarchy of technological capabilities that shows that enterprises do not operate on a level playing field. For instance, SMEs lack the in-house skills to access incentives. To overcome the challenge facing SMEs in Austria, tax incentives have been made available to start-ups before any profit is even indicated (OECD, 2008). Other countries have adopted technology voucher schemes to provide assistance to small firms that lack in-house technology expertise, which can be adopted in South African NSI. The adoption of hierarchy of technological capabilities and international country strategies implies the need to have in place sufficient well-informed and skilled intermediaries available in public sector agencies to facilitate transitions to more sophisticated levels of capability.

With regard to SD in South Africa, the Trialogue's CSI Handbook (2010) provides innovation for development survey information which, among other, analyses in the report, confirms the 'scatter-shot' effect of the considerable R5.4 billion in South Africa's CSI expenditure, distributed across

12 development focus areas. The novel notion of a Triple Bottom Line (TBL) (planet, people, profit), which was coined by Elkington (1994), urges organisations to include social and environmental responsibility in the economic endeavours. The TBL responsibility includes sustainable business development (SBD) principles involve Life Cycle Thinking (LCT) and thinking about all of the effects, impacts and consequences of planet, people, profit from "cradle-to-grave" (Rainey, 2006:713). It can therefore be proposed that South Africa's private enterprises should undertake innovation for development through (i) corporate social investment (CSI); (ii) broad-based black economic empowerment (BBBEE) schemes; (iii) the green economy and more labour-absorptive production methods; (iv) social entrepreneurship as a means of advancing development goals; and (vi) philanthropists and 'philanthrocapitalism'.

4.8.10 University/Higher Education Institutions Landscape

This section presents a literature review on the role of HEIs within the NSI. This study maintains both an 'outward' and an 'inward' dimension in examining the role of HEIs. Inwardly, the research reviews the HEIs landscape in South Africa, while outwardly; the central issue is the identification of specific mechanisms for constructive collaboration between the HEIs and other NSI actors. It can be recognised that the HEIs are an essential contributors to SD through the production of knowledge, skills and innovations needed to drive the regional and national economies. Literature such as Lall and Petrobelli (2002), Srininvas and Sutz (2008), and Bell (2007) shows that HEIs plays a pivotal role in research and incubation of scientific and technological innovations that promote real and sustained economic and social development. However, given the limited funding and financing challenges, many African HEIs are under increasing pressure to demonstrate their social and economic relevance (Lundvall, 2007). Dialogue on triple helix, with reference to HEIs-industry linkages, is increasingly becoming part of the fore in HEI policy in Africa.

The HEIs governance systems is characterised by autonomy and accountability. Autonomy captures the extent to which institutions are free to manage their resources and to shape their activities. Accountable systems provide incentives by allocating resources on a performance basis and by evaluating outcomes (Veugelers et al., 2009:248). South Africa's HEIs enjoy autonomy in the form of financial, staff policy, with respect to hiring/firing and wages, student selection and course content and accountability in the form of evaluation mechanisms and funding rules. Although there is no step-by-step framework that describes how HEIs-industry linkages are to be developed and implemented, three conceptual frameworks that have been used to provide the theoretical underpinning for supporting these linkages are: (i) NSI (iii) triple helix model; and (ii) Mode 2 Knowledge Production. According to the SA DoE (1997:2.82) White Paper 3, the production, advancement and dissemination of knowledge (research) and the development of high-level human resources are core functions of the higher education system. Within the NSI, HEIs are important generators of new ideas and promoters of innovation (Etzkowitz et al., 2007:11). The framework underpinning the review of South Africa HEIs is illustrated in Figure 4.8.10-1. Two juxtapositions have shaped the structuring of curricula discourses in South Africa, namely: the National Qualifications Framework and traditional disciplinary discourse (Ensor, 2002:274-275).

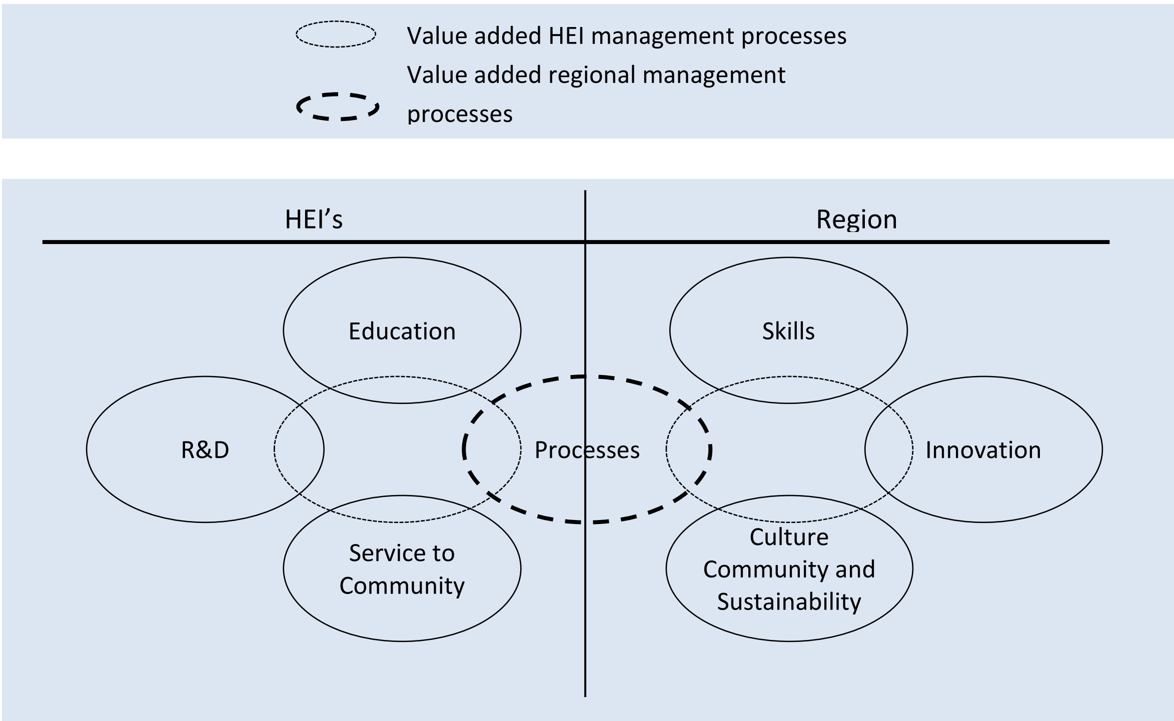
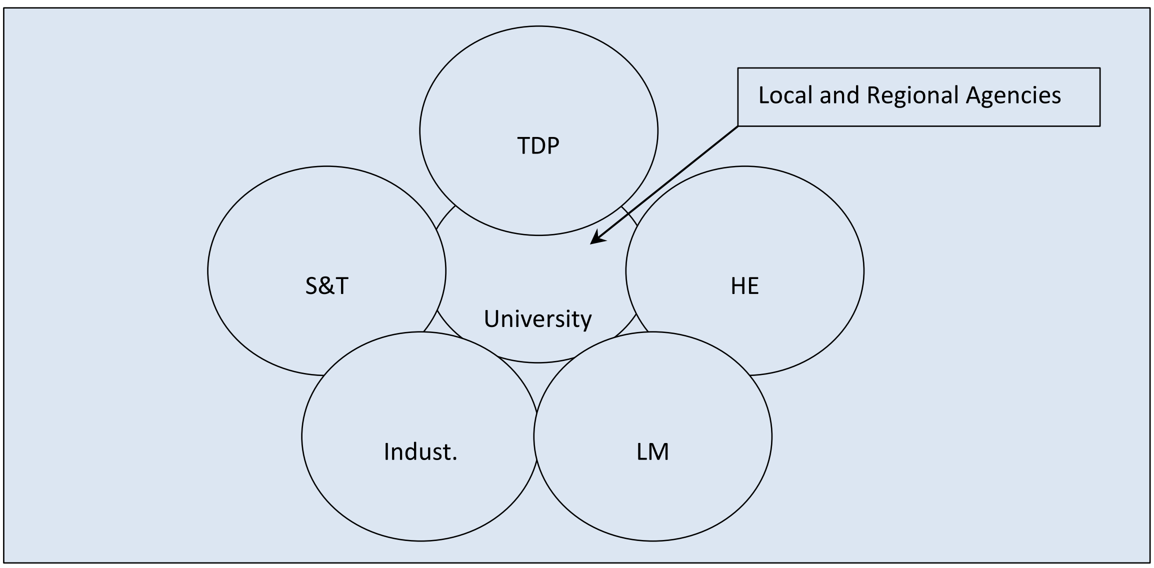


Figure 4.8.10-1: Closed model of the interface between region and higher education institution
Source: Adopted from Goddard and Chatternon (2003)

The left side of Figure 4.8.10-1 refers to the three conventionally identified roles of HEIs (teaching, research and community engagement (CE)) (Chatterton & Goddard, 2003). The right side of Figure 4.8.10-1 summarises three key dimensions to (sustainable) development, namely: innovation, skills and cultural and community cohesion including three pillars of sustainability. Successful development requires drawing together the three strands for the HEIs' effective engagement. In South Africa, the Higher Education Act No. 101 (1997), amended in 1999, 2000 and 2001 and the White Paper provide the overall regulatory and policy framework for HEIs, which places overall control of the HEIS in the hands of the Council. The S27 (1) provides that the Council "must govern" the University "subject to the Act and the Institutional Statute." According to S28 (1), the Senate is answerable to Council with respect of academic and research issues. The CHE is an independent statutory body established by the Higher Education Act (1997). Its mandate is to advise the Minister of Education on all matters of higher education so that the system becomes characterised by equity, quality, responsiveness to economic and social development needs, and effective and efficient provision and management and also contributes to the public good. While the number of HEIs has been reduced from 36 to 23, largely by merging technikons (technical colleges or polytechnics), the higher education sector as a whole has expanded dramatically since 1994, with the number of students rising from 473 000 in 1993 to 718 00025 by 2003. However, drop-out rates appear to have been rising in line with the increasing proportion of students from disadvantaged backgrounds in the higher education system. By restructuring the HEIs system in the White Paper was aimed to:

> Deliver the requisite research, the highly trained people and the knowledge to equip a developing society with the capacity to address national needs and to participate in a rapidly changing and competitive global context the South Africa Department of Education (White Paper of S&T, 1997:1.13).

At the national level, at the HEIs the main National policies impacting on HEI/regional relations include: (i) Science &Technology (S&T); (ii) territorial development; (iii) HEIs; (iv) labour market; (v) industrial policy. Figure 4.8.10-2 presents and illustrates national policies impacting on university/regional relations.



National policies impacting on university/regional relations

Key:

S&T	Science and Technology
TDP	Territorial Development
HE	Higher Education
LM	Labour Market
Indust.	Industry Policy

Figure 4.8.10-2: National policies impacting on university/regional relations
Source: Chatterton and Goddard (2003)

According to the OECD (2007b:187), the number of higher education researchers has stagnated for some years. (Paterson, Nesamvuni & Canca, 2005:15) notes:

> South Africa's scientific output has been stagnating for the past 10-15 years. Stated differently, the scientific output of public science has reached a steady state. The output is typical of a system which has reached its limits. Unless the system changes structurally, no substantial growth is likely. In fact we would predict that no amount of incentives and rewards will affect this situation in the short term.

According to Centre for Higher Education Transformation (CHET, 2003:4) engagements refer to a systematic relationship between HEIs and their environment characterised by mutually beneficial interactions. Engagement entails incorporating feedback into changes in research and curriculum in the institution (CHET 2003: 10). Adopting Gibbons et al. (1994) terminology compared to Mode 1, Mode 2 knowledge is rather a dialogic process and has the capacity to incorporate multiple views, which relates to researchers becoming more aware of the societal consequences of their work ('social accountability').

Sandman (2008:100) views engagement as the process of transferring, applying and sharing the university`s knowledge resources and expertise with those of the public and private sectors to enrich scholarship, research and creative activity; enhance the curriculum, teaching and learning; prepare educated and engaged citizens; strengthen democratic values and civic responsibility; contribute to public good and transformation and to enhance social, economic and ecological sustainability (Sandman, 2008:100). Therefore an academic scholarship based model of CE involves both the act of engaging, bringing the HEIs and the community/stakeholders together as partners. Social engagements at the HEIs can take place in the form of community outreach projects, volunteerism, access and enrichment programmes (mathematics, science, engineering), clinical service and development projects, networking and stakeholder exchanges, information provision, student recruitment programmes, service learning, socio-cultural and sport activities, student placement/internship, serving on internal and external academic and professional committees and organisations, community organisations as well as serving on non-academic community organisations and committees. The CE activities illustrated in Figure 4.8.10-3 can be performed by academics, students, professional and administrative staff.

Therefore, the traditional role of CE can be replaced by the realization that within the proposed knowledge economy, research commercialisation and regional and national SD will add more value to the South Africa.

University

Academic Programs (Any Level)
Service Learning
Internships
Distance Learning

Research Projects
Participation
Project based learning

Engagement
Through Professional /Discipline Based Service Provision
Through Teaching and Learning such as short Courses
Voluntary Professional Service
Production / Presentation of Materials
Through Research and Scholarship

Community

Figure 4.8.10-3: Sample community engagement at the HEIs
Source: prepared for this research

The Scholarship of Engagement generally draws from many sources of distributed knowledge and is based on reciprocal partnerships that are mutually beneficial. It is shaped by multiple perspectives and expectations; is long term, both in effort and impact, often with episodic bursts of progress; requires diverse strategies and approaches; and crosses disciplinary lines (Holland, 2005; Fitzgerald, 2010).

The concept of the "entrepreneurial university" (Wolson, 2003:117), the controversy "The Kept University" (Press & Washburn, 2000) has not been unanimously accepted. Press and Washburn (2000:2) argued that: (i) the trend towards commercial activity occurs at the expense of the educational mission of HEIs; (ii) research agendas are dictated by corporate needs rather than by the public good, and that disinterested enquiry is inhibited; (iii) academic freedom is being restricted as researchers agree to abide by confidentiality clauses which can prevent publishing or discussing research work; (iv) conflicts of interest develop, particularly where researchers and/or the university are given the opportunity to share in a sponsoring company's profits; (v) institutions are growing increasingly fragmented as special interests are asserted by different groups.

In the HEIs context, grasping the necessity and bringing the TYIP to fruition are two different matters. In the South African context, unique opportunities and challenges facing the HEIs are overlaid by the dual imperatives of reconstruction/equity and development (SA DoE, 1997:2.95; Griesel, 2003:39). Multiple policy imperatives should be deliberately designed to steer the transformation of the South African HEIs landscape to shape the agenda of institutions and the HEIs system as a whole (Teichler, 1999:183).

In the proposed knowledge economy, achieving SD through research in the NSI will depend on the depth and width of South Africa's reservoir of HCD to support both the public and private enterprises.

4.8.11 Higher Education Institutions and Intellectual Property Management

HEIs are facing increasing economic pressure on academic research, with the increased demand to participate actively in turning scientific developments into useful innovations (Veugelers et al., 2009:270), rather than shifting more towards producing pure applied research and/or supply innovations to the market (Veugelers et al., 2009:270). A wider and deeper interaction between the productive sector and the HEIs, fully respecting the division of labour between commerce and academia can therefore be proposed. This study adopts the definition of IP according to the IP Act of 2008 as:

> "any creation of the mind that is capable of being protected by law from use by any other person, whether in terms; of South African law or foreign IP law, and includes any rights in such creation, but excludes copyrighted works such a thesis, dissertation, article, handbook or any other publication which, in the ordinary course or business, is associated with conventional academic work".

According to section 9 of the IPR-PFRD NIPMO Act 2008, NIPMO is mandated to promote the objects of the IPR-PFRD NIPMO Act. According to the Act (2008) as one of the functions "NIPMO must promote the objects of this Act, which includes the statutory protection, management and commercialisation of the IP referred to it by a recipient in terms of section 4". The objectives of the IPR-PFRD Act, 2008 is to provide for more effective utilisation of IP emanating from publicly financed R&D; to establish the NIPMO and the IP Fund; to provide for the establishment of offices of technology transfer at institutions; and to provide for matters connected therewith (South African Intellectual Property Rights, 2008). The Act also seeks to ensure that:

i) A recipient of funding from a funding agency assesses, records and reports on the benefit for society of publicly financed research and development;
ii) A recipient protects IP emanating from publicly financed R&D from appropriation and ensures that it is available to the people of the Republic;
iii) A recipient IP emanating from publicly financed R&D;
iv) Human ingenuity and creativity are acknowledged and rewarded;

v) The people of the Republic, particularly small enterprises and BBBEE entities, have preferential access to opportunities arising from the production of knowledge from publicly financed R&D and the attendant IP;

vi) Following the evaluation of a disclosure, researchers may publish findings for the public good; and

vii) Where necessary, the State may use the results of publicly financed R&D and attendant IP in the interest of people of Republic (South African Intellectual Property Rights, 2008:5-6).

According to section 6(1) of the Act, 2008 HEIs are required to establish a technology transfer function at and 7(2) (a) which says that an IP policy is required. The Act (2008) states that “unless determined otherwise by the Minister in consultation with the Minister responsible for higher education, or any other Cabinet minister to which an institution reports, any institution must, within 12 months of the coming into effect of this Act (a) establish and maintain an office of technology transfer; or (b) designate persons or an existing structure within the institution to undertake the responsibilities of the office of technology transfer.

The South African IP regulatory environment, although well intended (involving clinical trials, field trials and bio-prospecting) is increasingly burdensome for the NSI network users. The South African TIA has taken too long to become operationalised and has, thus, introduced further delays and uncertainties for beneficiaries. The Intellectual Property from Publicly-funded Research Act (Act No. 51 of 2008) may facilitate the IP process; the delays inherent in the new NIPMO suggest that there may be more problems in the future. This research is of the view that a coherent plan or principles on the South African IP process should be undertaken, formulated and implemented.

4.8.12 Higher Education Institutions and Sustainable Development

Glasser, Calder and Fadeeva (2005:7-8) offer a broad definition of Research higher education sustainability (HES) to refer to:

> *“Any research that is directed at advancing our ability to incorporate sustainability concepts and insights into higher education and its major areas of activity: policy, planning, and administration; curriculum/teaching; research and scholarship; service to communities; student life; and physical operations/infrastructure. It also refers to research that treats higher education institutions as complex systems and focuses on the integration of sustainability across all of its activities, responsibilities, and mission. Research in HES includes six general focus areas: (i) defining and envisioning “Higher Education for Sustainability;”(ii) integrating sustainability into higher education activities and responsibilities; (iii) assessing how well academic institutions incorporate and model sustainability;(iv) improving the ability of scholars to teach about sustainability or incorporate sustainability concepts and principles into courses,*

curricula, disciplines, and research programs; (v) addressing questions—in science, technology, social science, or the humanities-that are crucial to our transition to a sustainable future; and, (vi) addressing processes for social learning, innovation diffusion, knowledge transfer, policy analysis, decision-making, and educational reform that are crucial for our transition to a sustainable future" (Glasser et al., 2005:7-8).

Glasser et al. (2005) definition demonstrates that there are many types of research along the continuum of sustainability ranging from the specific (engineering research that produces widgets for improved energy efficiency) to more philosophical (examining the premise of sustainability).

The HEIs becomes the "principal signifier of cultural capital" with HEIs producing, not simply reproducing or reflecting, social hierarchies (Scott, 1996: 47). Scholars such as Schumpeter (1934:1947), Schultz (1981), Cardoso and Faletto (1979), Webster (1984), Lall and Petrobelli (2002), Srininvas and Sutz (2008), and Bell (2007) have, over a long period, recognised education as critical to (sustainable) development. Eriksson (2006:22) notes that "practical and empathetic understanding of the existential situation of fellow human beings must be viewed as a form of knowledge in its own right. This knowledge should be a valid field of higher education and research and a challenging area for intellectual discourse and debate". Bordt, Rosa and Boivin (2007:266) add that the integration of SD and innovation in "a sustainable growth strategy has to be endorsed on a higher institutional level, in the form of a social contract and/or long-term planning objectives that set new standards". According to Wals (2006:108) the brightest minds on the planet should be utilised to find ways to preserve, rather than to destroy the planet. The biggest handicaps contend Ferrer-Balas et al. (2006:27), are the traditional resistance to change in HEIs and the high level of "irrationality" of the decision-making process. Globally, HEIs have been criticised for lack of response towards sustainability. As cited in Ferrer-Balas et al. (2006:28), in the UK for example, in 2003, the House of Commons Environmental Audit Committee noted:

> We are disappointed at the dismal response shown by the Government and the majority of Further and Higher Education Institutions (FHEIs) to the Toyne Report and its review. …The Toyne recommendations have clearly not spurred the sector to embrace sustainable development. Although, they have given those who were already starting to explore sustainable development, a framework to build upon …."

The HEIs have turned into the greatest societal welfare institution in and one that is almost impossible or hard to steer (Lundgren, 1977; Wickenberg, 2006). With regard to the slow response by the HEIs, Scott and Goug (2006:90) state that:

> "…All this reflects the notional independence of … Universities from government, where a university is quite likely to say: we agree sustainable development is important, but it's not government's place to tell us what to do; we shall think that through for ourselves, according to our own situation. There is a fine line between offering support to the higher education sector, and steering it in a particular way…."

Scott and Goug (2006:94) further note that:

> In discussions around sustainable development and higher education, the idea of barriers features strongly, and these are viewed as impediments to progress to be side stepped, vaulted over, hurled aside, or cast down in one way or another. This negative [barrier = obstacle] perspective is commonly found in the fields of institutional development and the management of change, as well as in wider society where all sorts of barriers are striven against through social policy: for example, the glass ceiling, poverty, illiteracy, access to education, and discrimination on grounds of age/gender/sexuality/ethnicity/…

Sterling (2005) supposes that the nature of sustainability requires a fundamental change of epistemology and, therefore, of education. Sterling (2005:6) writes:

> Sustainability is not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organisational change, of policy and particularly of ethos. At the same time, the effect of patterns of unsustainability on our current and future prospects is so pressing that the response of higher education should not be predicated only on the 'integration of sustainability' into higher education , because this invites a limited, adaptive, response…. We need to see the relationship the other way around—that is, the necessary transformation of higher education towards the integrative and more whole state implied by a systemic view of sustainability in education and society.

According to Lotz-Sisitka and Lupele, (2006:53) in responding to the challenges facing African HEIs, agents in African HEIs will no doubt need 'their wits about them' to navigate the structural and cultural factors influencing Africa's development path and 'own' HEIs contexts. Burnes (1996:121) classify two basic organisation structures namely: the m*echanistic structures*, which are command and control based and the o*rganic structures*, which are open and less rigid. Generally, HEIs can be categorised as being more of a mechanistic structure, reflecting the university's traditional and classical origins, the middle ages, rather than the industrial revolution and this medieval origins continue to influence the organisation and operation of the university (Mowery & Sampat, 2007:9). Integrating SD somehow contradicts the fundamental design principles embedded in traditional organisations. Some of the significant documents identified by this research that should be used to inform South African HEIs SD efforts include the Baltic 21 (2004) and the Higher Education Funding Council for England (HEFCE, 2009:3). The Baltic 21 (2004), for instance, has adopted a visioning strategy to signify the importance of integrating SD into the HEIs. Using the ten year benchmark, the HEFCE (2009:3) vision states:

> The higher education sector in this country will be recognised as a major contributor to society's efforts to achieve sustainability – through the skills and knowledge that its graduates learn and put into practice, its research and exchange of knowledge through business, community and public policy engagement, and through its own strategies and operations.

The HEFCE vision is based on the notion that HEIs have a pivotal role in enacting SD because of the core activities of teaching and research (Martin, Dawe, Jucker & 2006:61). The HEIs and individual academics have interests in relation to SD through research, consultancy, teaching, and management (Scott & Goug, 2006:89). The UNESCO (2005:11) identifies two unique opportunities for HEIs to engage in SD. First, HEIs form a link between knowledge generation and transfer of knowledge to society for their entry into the labour market. Second, HEIs actively contribute to the societal development through outreach and service to society. According to Cortese (2003:17), HEIs bear a profound, moral responsibility to increase the awareness, knowledge, skills, and values needed to create a just and sustainable future. The main objective of UNESCO ‘Decade of Education for Sustainable Development’ is to “integrate the principles, values, and practices of SD into all aspects of education and learning” (UNESCO, 2005). Educators and researchers can contribute to securing a safer and more sustainable future against recognised threats such as climate change and global poverty.

Integrating research, education and university operations in a comprehensive strategy can be based on the model illustrated in Figure 4.8.12-1, which underlines the outputs that come from the three areas together with the flows that cross between them, which are synergetic effects that also have to be promoted. The balanced progress in the three areas provides mutual reinforcement for achieving the overall objectives of SD in the university (Ferrer-Balas et al., 2006).

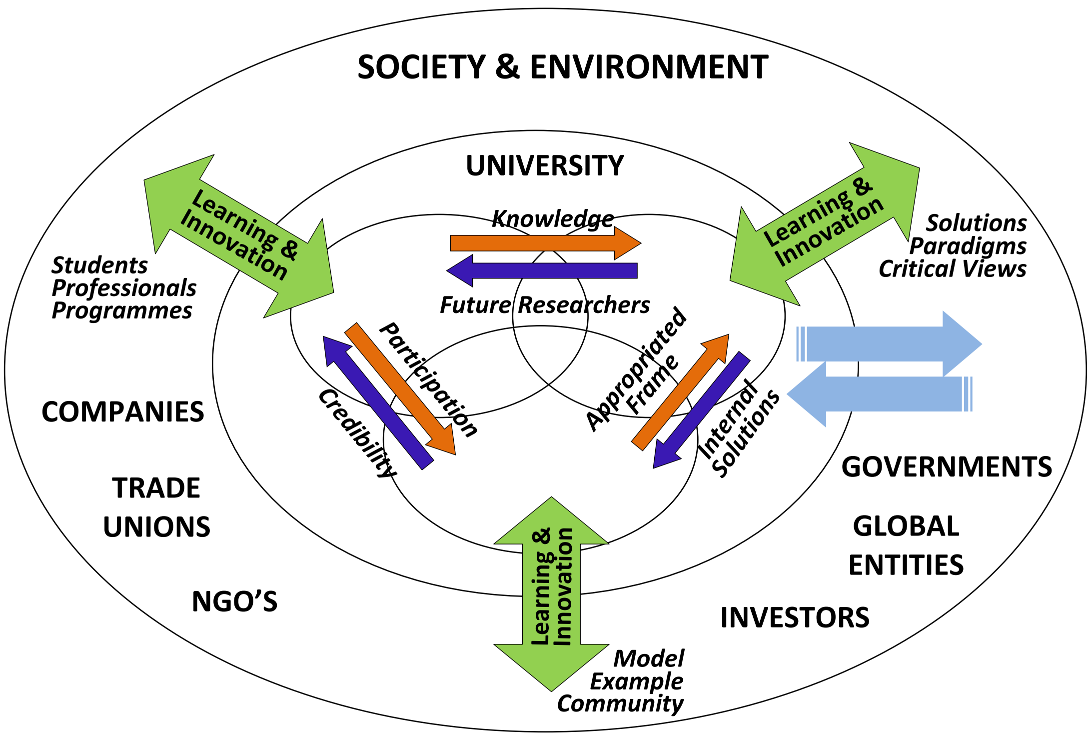


Figure 4.8.12-1: Integrating HEIs operations in a comprehensive strategy
Source Ferrer-Balas, Cruz and Segalàs (2006:24)

Figure 4.8.12-1 indicates that the HEIs can benefit from the outside worlds' interest in SD through efficient interface with stakeholders (Ferrer-Balas et al., 2006:28). According to Centre for Development and Enterprise (CDE, 2000:4) "South Africa's universities have by and large not adapted to the economic needs facing South Africa, and are not sufficiently responsive to business's needs". According to Stumpf (2011), the South Africa's HEIs system is locked in stasis, heavily stabilised and constrained within itself due to policy fatigue in terms of policy and practice. The findings by Stumpf (2011) can be summarised as: (i) the HEIs is characterised by low graduation rates and high drop-out rates, which has a negative consequence in transitioning into the knowledge economy; (ii) during the past decade, strengthening universities of technologies has proved difficult as well as in increasing share of student enrolments; (iii) significant barriers to the expansion of the postdoctoral sector continue to exist in the HEIs. Much-improved functionality in HEIs simply has to be achieved in order to increase access, and to raise participation and completion rates (Stumpf, 2011). This research posits that a concerted, innovative approach must be adopted to allow the HEIs to overcome the constraints that still shackle it despite the structural interventions during the last decade.

The SA DoE National Plan for Higher Education (2001b) provides that "the strategic framework for re-engineering the higher education system for the 21st century" poses the question whether HEIs are indeed geared towards addressing the human resource skills shortages facing South African. The HEIs are less equipped "to steer these processes systematically than (they are) to shape the cognitive domain of academic learning" (Brennan, Kogan & Teichler, 1999:15). The DHET Strategic Plan (2010-2015) asserts that the differentiation debate in the HEIs is not concluded and that the HEIs are currently differentiated by institutional type, as well as on-going differential resource allocations using indicators such as student enrolments, research output and the number of academic staff with doctorates, student success and institutional size. A national task team has been constituted by the Minister of DHET to review the HEIs funding regime and promote a differentiated system that will meet a diverse set of equitable goals. This research perspective, HEIs will have to participate in shaping the national policy debates, which implies that clarity in respect of the institutions academic and organisational identity is a pressing strategic priority since this will influence how each of the HEIs are perceived.

4.8.13 Critical Issues and Key Challenges Facing Higher Education Institutions

In the South African context, unique opportunities and challenges facing the HEIs are overlaid by the dual imperatives of reconstruction and development (Griesel, 2003:39). The NSI will be a hollow aspiration due to the inability to perceive that innovation in education and immigration as the key problem (OECD, 2007b:65-66; SA DST Ministerial Review Committee, 2012:90). This research observes that unresolved issues in the entire South African education system have remained a bottleneck in the transition towards the proposed SA DST TYIP (2008) knowledge economy. Addressing the scarcity of engineering professionals, for example, will require a two-stage process, of providing a HEIs qualification, followed by a comprehensive workplace-based training towards professional registration (OECD, 2007b:65-66). A strong policy focus is critical for an enlarged engineering capability (Foray, 2010:102). Engineering disciplines in this research context relates to both hard sciences (mechanical, electrical, computer, among others) and the social sciences or "service engineering" which deals with organisation and management practices (Foray, 2010:102). Towards addressing the bottleneck, the SA DST Ministerial Review Committee (2012:90) states that "good-quality, high-capacity training programmes in the S&E to implement new technologies is often rooted in the interface between the social and the technical". The inclusion of a fifth five Grand Challenge, the 'Human and Social Dynamics' is a major positive commitment by the DST's TYIP (2008) towards the knowledge economy. However, the DST's TYIP (2008:30) plan for South Africa's PhD production in S&T to grow fivefold, to about 3 000 SET PhDs by 2018 should be reviewed in the light of the aforementioned bottleneck. There are only about 5,500 academics at South African universities with PhDs and who can supervise, with a current average of one PhD every four years. CREST study by Mouton (2013:2) identified a number of crucial supervisor-related determinants of PhD production: "huge differences" in supervisor knowledge, competence and style, a growing supervision burden and differing levels of institutional support in terms of scholarships and bursaries, research facilities and equipment and institutional policies.

The complex nature of NSI human resources and capital issues produces a more complex epistemological challenge, beyond requiring the HEIs to simply change the curricula and research priorities. Combined age and race data suggest that a serious crisis in the HEIs (CHE, 2004:250), as a result of disciplinary ageing due to failure to produce next generation of scholars, the 'frozen demographics' (OECD, 2006:80). The HEIs will also have to take into account the additional academics required for the HEIs to expand as envisaged by the 2001 NP for HEIs and the TYIP, from the current gross participation rate of 16% to that of 20% by 2016.

South Africa has the fourth highest rate of HIV/Aids infection and tuberculosis (TB) in the world (WEF, 2013:46). According to the HSRC (2013) survey an estimated 6.4-million people were living with HIV/Aids in 2012. The estimated overall prevalence of HIV increased from 10.6% in 2008 to 12.2% in 2012. According to the HSRC survey, the increased prevalence of HIV in 2012 was largely due to the combined effects of new infections and a successfully expanded antiretroviral treatment (ART) programme (HSRC, 2013). Owing to the HIV/Aids pandemic, life expectancy in South Africa has decreased from 63 years in 1990 to just 51 in 2006 (WEF, 2013:46). The HIV/AIDS epidemic is of enormous significance in South African HCD (OECD, 2007b:13; CHE, 2004: 235-236; Higher Education HIV/AIDS Programme South Africa (HEAIDS, 2010). In Sub-Saharan Africa, life expectancy stagnated at 49.5 years between 1990 and 2000, a result of the HIV and AIDS pandemic. Between 2000 and 2012, however, life expectancy increased 5.5 years (UNDP, 2013:24). Addressing and tracking research progress and output is needed, as well effective strategies to maximise HEI's knowledge contribution in combating HIV and AIDS. The HEAIDS research revealed that certain sub-populations are more vulnerable to HIV infection: female students, older students, male staff, and African staff and students. This implies that the HEIs should put in place efforts to prevent the spread of HIV and to offer care, support and treatment to students and staff living with HIV.

There is a dearth of data on the mobility of highly skilled individuals, both outward and inward, as well a lack of database of Masters and Doctoral degree-holders. In South Africa a complete database is needed for the throughput of postgraduates, layered by level, discipline, source of funds, gender, group, social class, scholarship support, and nationality (SA DST Ministerial Review Committee, 2012:79). Unrestricted movement of talent and skills is important for South African HCD. The SA DST Ministerial Review Committee (2012:153) notes that "the free circulation is enshrined in the SADC Protocol on Education and Training, but South Africa's immigration regulations appear to be implemented in ways that frustrate the intent of the protocol". There are also a dearth of information on the production, retention, mobility, replenishment and turnover of public sector academics, researchers and demographics of science council staff (NACI, 2007). The availability of data and information on the patterns and interventions should facilitate shift performance curves in the right directions towards the proposed knowledge economy.

The DHET Task Team report of 2013 has set about an overhaul of the SETA, citing widespread corruption and inefficiency and suggests that the National Skills Authority (NSA) be disbanded. The DHET Task Team (2013:2) notes that "in terms of the Skills Development Act, the NSA must advise the minister on: national skills development policy; national skills development strategy; the allocation of subsidies from the National Skills Fund. "However, the NSA has not been able to fulfill all of the roles adequately". The DHET Task Team (2013:2) report adds that "the skills development and human resource development institutional landscape is currently composed of a wide range of existing structures that duplicate functions. As a consequence, it has become increasingly unclear what role an institution such as the NSA can effectively play…a voluntary system would do away with all the negative perceptions and inefficiencies associated with SETAS" (DHET Task Team, 2013:2). However, Business Unity South Africa (Busa) supports a hybrid option of improving the SETAS and NSA system, stating that "it is our view that many, if not all, of the current problems mentioned in the report could be resolved within the current framework and that an alternative system could equally well include these and other problems if it is not properly managed". Having examined the triple helix model within the South African NSI, the next section presents the South African NSI strengths and weaknesses.

4.9 STRENGTHS AND WEAKNESSES OF THE NSI COMPONENTS

The sub-section reviews literature with regard to the strengths and weaknesses in the functioning of the South African NSI. Table 4.9-1 is a summary of South Africa's strengths, weaknesses, opportunities and threats (SWOT), which is discussed in this sub-section.

Table 4.9-1: Summary of South Africa's strengths, weaknesses, opportunities and threats (SWOT)

STRENGTHS	OPPORTUNITIES
• Resource-based industries and related knowledge-intensive business services (KIBS) • Knowledge infrastructure, albeit small in relation to the size of the overall population • High proportion of BERD in GERD • Tradition of linkage between major industries and the knowledge infrastructure • International industrial and academic networks • Political awareness of the importance of STI for sustainable growth • Open, participative governance with mechanisms in place for cross-departmental co-ordination	• Raise economic performance by building on existing innovation system strengths in industry –including large firms – and the knowledge infrastructure • Investment boom provides window of opportunity for technology development, acquisition and learning and increasing absorptive capacities • Attract foreign direct investment (FDI) to establish durable South African capacities • Exploit latent talents of the majority • Build on industry-research sector interactions as "focusing devices" for developing the knowledge infrastructure • Revise mental models of how the innovation system operates to put producers in the centre • Further modernise the state's role in the innovation system via "agencification" and the creation of a national policy arena
WEAKNESSES	**THREATS**
• Poor quality schooling for many citizens • Human resource shortages at all levels in mathematics and S&T • Lack of design, engineering, entrepreneurial and management actors (DEEM) and R&D capacity leading to an "engineering gap" • Ageing, white, male dominance of industrial and academic R&D • Mental models of how the innovation system operates overly focused on the role of the state	• HIV/AIDS • Social unrest, if the pace of development falters • Demographic pressures on education, research and innovation systems caused by a large increase in the cohort of people born in the 1990s

• Governance of the state components of the innovation system insufficiently holistic • Strategy implementation capacity in the state's part of the innovation system • Use of "level playing field" idea in funding higher education impedes the development of new institutions • Large "second economy" with insufficient entrepreneurial and technological skills • Inconsistencies between immigration policies and the human resource needs of the NSI	

Source: OECD (2007b:11)

Most of strengths associated with the South Africa NSI have been integrated in previous chapters of this research literature review. The SA DST (2002:21-22) outlines six key weaknesses in realising the White Paper of S&T vision, namely: appropriate funding of the NSI, strategic issues, human resources challenges, declining R&D in the private sector, the fragmentation of government S&T and IP issues.

4.9.1 Strengths

Some of the key strengths and opportunities of South Africa's NSI are outlined in Table 4.9-1, which, since 1994, includes improved governance structure, a dedicated government and institutions such as the DST, DTI, the NRF, and NACI. Initiatives such as the THRIP have been successful in promoting cooperation between the HEIs and industry sector. South Africa's R&D-related assets include a strong, yet very limited, set of established HEIs, a good system of research councils and a nucleus of technologically-strong, innovation-performing business enterprises (NACI, 2007:79-80). The CeSTII undertakes basic R&D and innovation surveys that build analytical work on the results. During the last five years, the R&D expenditure by business enterprises has been on the raise and constitutes a larger fraction of total R&D than in most other economies with similar levels of per capita GDP or similar R&D/GDP ratios. The business sector funds 45% of formal R&D and performs 58% of R&D.

In South Africa, three programmes aimed at strengthening research and increasing human capital within the HEIs sector include the Research Chairs Programme, the Prestigious Post-Doctoral Fellowship Programme Pilot (R150 million per year) and the Professional Research Development Programme (R15 million per year). South Africa has a broadening nucleus of technologically strong, innovation performing business enterprises. It also has a strong information communication infrastructure, which caters for global astronomy communities such as the MeerKAT, SANReN and SKA projects. Also the country has developed a strong capability to provide strategic intelligence and analysis to support policy.

Even though the South African Patents and Trademarks Office (SAPTO) have limited capacity compared to other LDC, South Africa has a relatively well-developed IP framework. The framework is largely influenced and informed by the World Trade Organisation-administered Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Two initiatives have come out of the DTI: a sub-committee of the Standing Advisory Committee on Intellectual Property Rights has been tasked with proposing improvements to legislation dealing with the management and commercialisation of IP, especially when developed as a result of public funding, while a joint project between the CSIR and SAPTO has a similar brief. However, how the two DTI initiatives will link up with each other is not clear.

4.9.2 Weaknesses

This sub-section reviews the weaknesses attributed to the functioning of the South African NSI, some of which have been presented in Table 4.9-1. The weaknesses are presented in a critically constructive manner for SD through research in the NSI. The weaknesses within the South African NSI appear to be limited by several shortcomings involving policy perspectives, processes and organisational structure such as vertical specialisation and differentiation and horizontal integration and co-ordination issues.

One major weakness within the NSI literature is the differing interpretation and definitions. For instance, some scholars deny 'the use of a system approach' (Walters, 2001:9-11), opting for 'process improvement' and 'system values' (Bekkers et al., 2011b:211). The current STI-focused approach and interpretation of the South African NSI is not wholly consistent with the systems approach. The concept of 'NSI' has yet to gain currency of being wider than traditional R&D activities and being fully absorbed into the strategies of key actors. In general, according to the OECD (2007b:13), "there is no clear understanding of what the contribution of the overall innovation system actually is, and hence no basis for assessing whether or not it is adequate". Where there are far-sighted initiatives (often from DST), the initiatives may find only limited effect in implementation due to the uneven commitment and the inevitable silo-effect of organisational boundaries, or simply a skill shortage.

Owing to differences in socio-historical and economic structures, the NSI framework is not intended to provide a "one-size-fits-all" (Bell & Pavitt, 1993; Schneider, Barron & Fonn, 2007), especially in LDC context. However, despite the wide acceptance of the innovation systems approach, policy decisions are largely reliant on the S&T approach. As a consequence, government initiatives have mainly focused on outputs indicators such as R&D, technical manpower, patents and scientific publications. The conventional indicators do not offer convincing explanations of trends in innovation, growth and productivity (OECD, 2007b:15). The application of aggregate statistics can hide major inefficiencies in specific sets of institutions within the NSI. The OECD (2010b:84) cautions that "indicators must be used with care and single indicators do not always tell the story that the inexperienced policy analyst, or general user may assume". Statistics and indicators can also be abused if not formulated from an arm's length from the policy process. In Jensen et al. (2007:684) terminology, "…when one turns to policy analysis and prescription, as well as to the quantitative survey-based studies that support and justify policy, … contend there is a bias to consider innovation processes largely as aspects connected to formal scientific and technical knowledge and to formal processes of R&D". Therefore, developing desegregates statistics to comprehend some observed yet unexplained X-inefficiency of the system as a whole is crucial (Ammons, 1996; Niosi, 2002:299). The Oslo Manual recommends the collection of data on barriers to innovation activity (OECD & Eurostat, 2005). Table 4.9.2-1 lists some of the factors that could act as barriers to innovation in South Africa.

Table 4.9.2-1: Factors hampering innovation activities

COST FACTORS:
• Excessive perceived risks
• Cost too high
• Lack of funds within the enterprise
• Lack of finance from sources outside the enterprise: o Venture capital o Public sources of funding
KNOWLEDGE FACTORS:
• Innovation potential (R&D) insufficient
• Lack of qualified personnel : o Within the enterprise o In the labour market
• Difficulty in finding partners for : o Product or process development o Management partnerships
• Lack of information on technology
• Lack of information on markets
• Deficiencies in the availability of external services
• Difficulty in finding co-operation partners
• Organisational rigidities within the enterprise: o Attitude of personnel towards change o Attitude of managers towards change
• Marketing partnerships

•	Managerial structure of enterprise
•	Inability to devote staff to innovate
	MARKET FACTORS:
•	Uncertain demand for innovative goods or services Potential market dominated by established
•	**INSTITUTIONAL FACTORS:**
•	Lack of infrastructure Legislation, regulations, standards, taxation Weakness of property rights
	OTHER REASONS FOR NOT INNOVATING:
•	No need to innovate No need because of lack of demand

Source: Adopted from Oslo Manual OECD and Eurostat (2005:12)

During data analysis, the factors in Table 4.9.2-1 were explored from the National Survey of Research and Experimental Development in South Africa: Main Results 2009/2010. Nevertheless, the national survey can 'hide' low patenting and international impact of business innovation.

Other weakness relate to the functioning of the NSI. In South African, although strides have been made in overcoming the fragmented NSI system, coordination issues present challenges in achieving national development priorities. Figure 4.9.2-1 presents the most problematic factors for doing business within the South African NSI, which indicate that the South African NSI is not yet open and permeable enough.

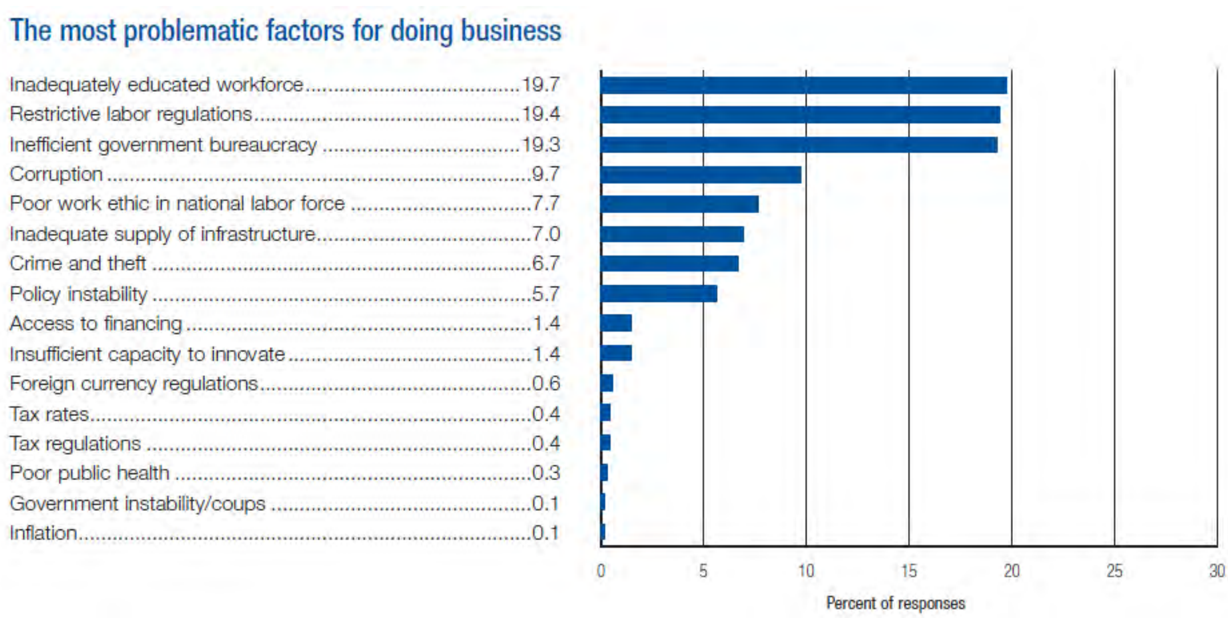


Figure 4.9.2-1: The most problematic factors for doing business within the South African NSI
Source: WEF (2013:346)

As supported by Figure 4.9.2-1, in the absence of coordination, the South African NSI may be under threat from various forces which include political, social, economic that push for ‘own’ policy agenda in the system. For instance, in the domain of social innovation, the lack of clean water can be viewed as a technology failure and therefore a 'problem of the NSI’. However, 'hard' technologies are well comprehended within the NSI, resulting in a failure in the 'political system'. The SA DST Ministerial Review Committee (2012:87) views such political weakness as an “indication of absence of clearly exercised political will…” Knutsen (2004:16-17) in reference to the sub-optimal NSI performance, states:

> “It is reasonable to question the current level of fragmentation. The NRF has attempted several times to encourage not only inter-institutional collaboration, but also collaboration with the same institution and sometimes within the same department. The reaction has been slow and sometimes the resistance is obvious. Activities that are sub-critical in size do not guarantee sustainability of the research operation … (but) … there is light at the end of the tunnel in that concerted efforts are being made by DTI, through the National Advanced Manufacturing and Logistics Technology Strategy, to embrace the existing knowledge base in South Africa to develop knowledge networks to foster innovation”.

South Africa has experienced considerable NSI vertical and horizontal coordination difficulties that are a consequence of the current governance and institutional architecture of the NSI (OECD, 2006:80-82). The coherence and integration difficulties have led to insufficient linkage between the various levels of government, with consequently weak integration between national, provincial and local levels (OECD, 2006:79-81; 2007:231). Integration of research and innovation activities across the sectoral responsibilities are also strongly resisted within the South Africa NSI. Often, the risk of loss of control over activities or budgets is a key aspect, leading to inter-ministerial turf wars (Arnold & Boekholt, 2002:25). Many sectoral S&T services under-perform owing to a lack of shared comprehension because the trust placed in voluntary inter-departmental cooperation has not been realised. The agencies that do exist (science councils, funding agencies, and HEIs, among others) may be insufficiently differentiated, with a consequent diffusion of roles and a weakened capacity to fulfil specialised roles needed for a sophisticated and responsive NSI.

As a whole, the South African NSI performance measurement and evaluation framework is inadequate and incomplete. The OECD (2006:81) notes that within the NSI framework conditions, evaluations of the actual outcomes of the policy instruments are generally unavailable, or at best descriptive. The inaccurate databases have resorted to distorted and inadequate resource flows in the NSI, both in quantity and nature (SA DST Ministerial Review Committee, 2012:83). Using out-of-date indicators and figures can be misleading for policymakers, who require statistics that accurately reflect the current NSI situation in undertaking reform efforts (WEF, 2013:65).

Notable M&E and planning weakness within the NSI has hindered the functioning of the NSI due to absence of an assigned responsibility for ensuring the availability, collation, maintenance, analysis dissemination of NSI performance in the form of STI indicators (quantitative and qualitative). Foray (2010:103) states that "what really matters in NSI performance is not the best shot but the weakest link" which, in this research context, is particularly true when the weakest link is engineering science. Weak links exists within the general field-specific 'march of science', for example a mismatch between the police and health department forensic laboratories, due to out-dated technologies (SA DST Ministerial Review Committee, 2012:83-85). At present, there is no entity that has the capability to do system mapping, analysis, building, steerage, evaluation, learning and foresight for the South African NSI.

Failure of NSMM for SETIs, with a lack of information-gathering and analysis for effective agenda-setting and prioritisation in the functioning of the NSI agencies is another NSI governance-related weakness. The intrinsic constraint on the scope-of-function of the DST has been explicitly or implicitly, due to the introduction of the 2004 NSMM for public research organisations. The fragmentation and a distinct lack of systemic coherence are but two of the symptoms of dysfunction associated with the NSMM (SA DST Ministerial Review Committee, 2012:9-17). No prospective NSI planning as envisaged in the SA DST White Paper of 1996 has been achieved, resulting in lack of systemic coherence and lack of a common purpose between the private sector, government, HEIs and civil society. The governance role of the DST in the NSMM was firstly to be the development of policy on standards for SETis. However, the SETI review system is unpopular, because of reviving and recycling unresolved problems and is run down because of lack of support.

The SA DST TYIP's (2008:11-24) five 'Grand Challenges' spear-headed by the DST, are designed to steer the resource-based economy towards a knowledge-based economy. However, resolving the Grand Challenges has been problematic because the challenges have been assigned to and spread across the various operating domains of government departments, and priority areas such as energy generation, the bio-economy, S&T, climate change and human and social dynamics. A growing obsolescence of parts of the knowledge infrastructure is a major concern for realising the TYIP (SA DST Ministerial Review Committee, 2012:16), which can be attributed to a reluctance to close down failing programmes of innovation, a term referred to as 'exnovation' by Hartley

(2005). A major weakness in addressing the Grand Challenges has been the difficulties in finalising arrangements for public-private partnerships and the inability to replicate and mainstream innovations which has resulted in deep-seated gap between business and government. Similarly, the available but limited level of resources and investment is spread too thinly over a wide variety of disparate purposes and projects. The documentary basis for quantitative assessment of the NSI resourcing (funds) issues is underdeveloped and insufficient, resulting in constraining any policy development or corrective action required for a NSI. A key NSI concern is the inadequate base for evidence-based decision-making and, in many cases, weak accountability for the expenditure of public funds (SA DST Ministerial Review Committee, 2012:17). Specific knowledge gap pertains to the effectiveness of the financial incentives, both direct (in the form of transfers and grants) and indirect, that pass through the DST. Weakness within the South African NSI has resulted in the inability to attract funding for long-term implementation A comparison of the 2009–2010 R&D expenditure data with those for 2008–2009 shows a decrease in GERD as a percentage of GDP from 0.92 to 0.87 total 'real' spend of only 1.3%, while the total number of researchers and R&D personnel has generally been static. This research observes that social innovation issues for addressing the wicked challenges are absent within the social pillar in South Africa. For instance, HIV/AIDS has had a negative impact on the social fabric and on the South African economy (OECD, 2007b:103). Alongside the South African human and social costs, the high incidence of HIV/AIDS erodes South Africa's efforts to build a stronger and demographically restructured human resource (OECD, 2007b:13; CHE, 2004: 235-236).

Depending on the definition used, unemployment and poverty remain stubbornly high and affect the lives of up to about 40% of the population (OECD, 2007b:14). Impeding the functioning of the NSI is the deficit of HEIs-based research and research training and the serious deficit in high-order skills, particularly in the area of design, engineering, entrepreneurship and management (DEEM), which has been exacerbated by a global labour market that draws top talents towards the LDC (OECD, 2006:79-80).

The NSI theory and concept remains broad, largely focused almost exclusively on formal institutions and is viewed as lacking a strong theoretical foundation (Lundvall et al., 2002:221). As a result policy formulation is typically oriented towards fulfilling, expanding or reforming formal institutions (OECD, 2010a:133-140). The coexistence of "traditional" or "indigenous" knowledge and "scientific" or "modern" knowledge is a typical feature of LDC (Bell, 2006:6; Wamae, 2009:218). The important synergy between the persistence of economic dualisms, both formal and informal sectors, should not be underscored (Mbeki, 2003:24-27) as well as mechanisms to enhance indigenous knowledge (Sagasti, 2004:8; Forje, 2006:375). However, traditional knowledge systems are not well formulated, making them difficult to be proactive and adapt to new knowledge demands. The situation is exacerbated by the weak links between "traditional" and "modern" knowledge systems (Bell, 2007:62-72). Innovation should take place across and over the whole spectrum of economic sectors and activities (not only in high technology) and types (not just formal R&D) (Foray, 2010:96). The weak link in addressing the dualistic nature of knowledge systems in LDC presents another challenge in establishing mechanisms for strengthening the interactions that promote knowledge flows within and between the two knowledge systems. To this end, the next section presents the chapter summary.

4.10 SUMMARY

This chapter has examined the history, governance, present policies and institutional structure of the NSI. The chapter has provided a constructive blueprint for the South African NSI by providing with a powerful description of key innovation activities for S&T policymakers and scholars, which described South Africa's collective efforts in the NSI. A review of the terms that make up the construct of NSI, namely: national, system and innovation has been undertaken. An outline of the structure of the South African government NSI, which operates at four levels, has been discussed. Similarly, a review of the two main components of the innovation system, namely: education and research (or knowledge infrastructure), on the one hand, and the political system (or policy and governance), on the other has been carried out. The chapter has further examined the importance of policy learning, resting upon monitoring, measurement and evaluation and the use of funding as a key lever for steering the system. The chapter has made use of a tripartite model that reviewed literature on the structure of the three main actors and responsiveness of the South African NSI. A discussion of the strengths and weaknesses of the South African NSI has been examined, which indicates that the NSI faces two main challenges, namely: redressing past inequalities and strengthening, diversifying research capacity and keeping abreast with the emerging global trends.

The chapter has revealed that the 1996 White Paper on S&T articulated a compelling vision for the South African NSI that for SD (economic and social pillar, with exception of environmental pillar). However, the vision has not been adopted widely enough across the range of government departments to achieve the envisioned pervasive effect. The chapter has also shown that innovation activities as involving more than just formal R&D. However, R&D activities within the South African NSI appear to be highly fragmented, reflected by the limited level of coherence and coordination. The South African NSI actors and the system as a whole faces a shortfall and inadequate resource flow both in quantity and nature.

The main actors in the NSI are business (private sector and state-owned), government research laboratories and HEIs. The business sector either improves efficiencies through innovation. Government research laboratories and HEIs conduct research and develop skills, which can be undertaken in partnership with the private sector. The government departments contribute to policy development and improvements in public service delivery. The government plays various roles in the NSI, such as setting framework conditions, providing infrastructure in the form of services and utilities, promotion of HCD, acts as a bridge between HEIs and private sector commercialisation of research and performs research through research councils.

The chapter has also identified that there is a limited level in the inclusion of the role of the private sector. This is because the private sector's role been inadequately included in the conception and coordination of the South African NSI. The measures taken by the government has achieved only very limited horizontal and vertical coherence and integration of purpose and effort between the various agencies of the NSI. The chapter has also identified a shortage in HCD as a key weakness in South Africa and therefore, adequate knowledge infrastructure is a crucial condition for the well-functioning NSI. It is proposed that provision be made to strengthen the capacity of the NSI to operate as a distributed learning organisation that is responsive to signals from within the system and to the wider environment. The South African NSI should be conceived of as a responsive internationally open system, with in-flows and outflows to the wider environment. The next chapter examines the construct of SD through research in the NSI in the African region.

CHAPTER FIVE

NATIONAL SYSTEM OF INNOVATION AND SUSTAINABLE DEVELOPMENT TRENDS IN THE AFRICAN REGION

5. AFRICAN REGION NSI

Chapter Four examined the main features and performance, which is the history, governance, present policies and institutional structure of the South African NSI. Chapter Five examines the NSI across the African region.

5.1 INTRODUCTION

The chapter adds to the importance of intra-African region NSI dialogue and draws out both context-specific and generic country experiences that could inform policy developments in South Africa. The chapter reviews mechanisms employed for prioritisation, institutional make-up, framework conditions, modes of policy learning, human resources and human capital, knowledge infrastructure and knowledge transfer, performance measurement and evaluation, research and research commercialisation, innovation activities and innovation indicators in a range of LDC.

This chapter is organised as follows: section 5.2 examines trends in SD in the African regional context in terms of the business sectors (economic pillar), social equity and environmental sustainability pillars. Section 5.3 reviews literature with respect to innovation policy and governance in the Africa region. Section 5.4 is a review of the African region NSI: main features and performance. Section 5.5 entails a review of research and knowledge systems within the African region. Section 5.6 discusses the African region's development of innovation indicators for SD through research in the NSI. Section 5.7 undertakes a review of public administration and public policy in the African region. Section 5.8 is a review of the construct of SD through research in the NSI in other developing regions and section 5.9 presents the chapter summary. Reviewing the trends in the African region is vital as Ward (2011:14) predicts that the emerging-world will contribute twice as much as the developed world to global growth by 2050. In 2050, 30 top economies by GDP, 19 of them will be 'emerging' economies such as China and India being the largest and third-largest economies in the world, respectively (Ward, 2011). Having briefly introduced this chapter, the next section provides a review of SD trends within the African region in terms of the economic pillar, social pillar, the environmental pillar and trade and investment.

5.2 SUSTAINABLE DEVELOPING TRENDS IN AFRICA

This section examines SD trends in the African regional context. Developing countries face three broad complex sets of SD policy objectives, namely: promoting international competitiveness for the business sectors (economic pillar), social equity and environmental sustainability pillars. An added complexity is the relatively poorly documented nature of African epistemology because this research views the NSI as largely shaped by social, institutional and historical conditions. Lotz-Sisitka and Lupele (2006:49) maintain that the discourse of 'internationally acceptable standards' is, in many ways, retarding opportunities for deliberating African epistemologies as most African scholars attempt to compete according to the 'international standards'. Therefore, in this research context, trade, investment and technology are viewed as the primary drivers of SST in South Africa and in the African region. According to UNCTAD (2012:73), the growth pattern is path dependent. The pertinent question is not whether - but how - Africa can implement a strategy of SST. The differences in development stages observed in this literature review in the African region can be explained by differing rates in technology adoption (Kaldor, 1957: 594-621), which has led to the concept of 'technology-gap' (Fagerberg, 1988:88-95; Abramovitz, 1994:22-40).

Sustainability in national development requires a strategic approach, which is both long-term and integrated or "joined-up" in linking various processes and complex challenges of SD (OECD & UNDP, 2002; Economic Commission for Africa, 2010b). Table 5.2-1 presents a list of possible actors in the African region development field. The actors who influence policies in the African region are explored.

Table 5.2-1: Actors in development field: different stakeholders, different development

INSTITUTIONAL	STATE	IFIs	UN SYSTEM	CIVIL SOCIETY
Structure	Governments,	IMF, World	Agencies/NGOs	NGOs
Infrastructure	Infrastructure Bureaucracies, interest groups, parties, citizens	WTO, G7, central, international and development banks, Congress, the Federal	UN General Assembly, governments, ILO,WHO	People. Social movements trade unions, parties, firms, churches,
Locations	Capitals,	Washington DC	New York, Geneva, Nairobi	Dispersed
Development thinking	Economics (neoclassical to Keynesian), human development	Neoclassical economics, neoliberalism	Human development	Alternative development (and post development)
Disciplines	Economics, political science, public administration	Economics	Economics, political, economy, IR, political science	Sociology, anthropology, ecology, gender, cultural studies

Source: UNCTAD (2009:9)

As indicated in Table 5.2-1, the globalising discourse has had an effect in the arena of SD. However, Bissio (2002), Bond and Guliwe (2003) and Fisher and Ponniah (2003) question whether genuine SD can emerge from geo-political power relations and 'compradorism', indicating a need for policy critique as well as policy implementation (Lotz-Sisitka & Lupele, 2006:50). Touraine (2000:12) and Bourdieu (2003:14) caution against a 'fake universalism' set by neo-liberal orthodoxy, which uses universal definitions of a global development path and standards-based thinking. Nevertheless, the heuristic selection and innovation orientation in (African regions) leads to unpredictable trajectories that may inhibit or support innovation. For example, 2001 saw an acceleration of policy discussions on regional integration with the establishment of the African Union (AU) and the launch of NEPAD. At the highest political level, NEPAD provides a framework for addressing SD challenges in Africa (Economic Commission for Africa, 2010b:4), similar to the wicked challenges pointed out earlier. However, with the exception of the African STI Initiative and a number of less dynamic activities, the benefits of South Africa's involvement in the AU S&T activities, including those related to the NEPAD, have not been well documented.

The National Science Board (NSB, 2008) points to four areas of substantial capacity for sustainable growth and convergence. The first of the four areas is technological infrastructure such as domestic investments in R&D, education and imports of foreign knowledge. The second is the socioeconomic infrastructure, which covers broader educational achievements, economic institutions, such as physical and IP rights. The third is the productive capacity, which includes the physical and human resources available for the manufacturing sector. The fourth is the national orientation, which covers policies and attitudes that constitute a business-friendly investment climate.

The NSSD involves a broad range of stakeholders who need to undertake change towards SD (OECD & UNDP, 2002). An examination of the NSSD characteristics in African countries that participated in the research conducted by Economic Commission for Africa (ECA, 2010b:6) reveals that those countries that had developed and were implementing NSSDs had held multi-stakeholder consultations, organised training sessions and workshops and either established or designated national coordinating bodies.

Table 5.2-2 presents a summary of the NSSD process of selected countries context, which indicates that most African countries have developed and are implementing NSSDs. However, the types and approaches differ depending on the particular country context.

Table 5.2-2: National strategies for sustainable development process of selected countries

NATIONAL STRATEGIES FOR SUSTAINABLE DEVELOPMENT PROCESS OF SELECTED COUNTRIES
Algeria: The NSSD process entails revising/updating policies, strategies and plans in order to integrate the key characteristics of a SD strategy. Current NSSD updated after 2011, taking into account other policies, strategies, plans and programmes that are directly or indirectly related.
Tunisia: Tunisia has begun the process of updating its National Agenda 21, using participatory approaches. The updating is being done within the framework of eleventh development plan and process. To this end, the Tunisian common vision for SD was elaborated and adopted by the country's NCSD in 2005. Public consultations and dialogue were undertaken, to prepare the orientations for SD for the decade 2007-2016. A General Directorate for SD, established in 2006 within the Ministry of Environment and SD, has been charged with coordinating the NSSD development process.
Uganda: The Poverty Eradication Action Plan (PEAP) is revised every three years on average. The PSR 2003 brought together all available evidence on the progress made in the implementation of the PEAP and the outstanding key challenges. During 2003 and 2004, three major stakeholder workshops were held, bringing together over 1000 stakeholders from central government, local government, the civil society and private sector, for each workshop.
Mauritius: The development of the Reform Strategy document took into consideration the need to update policies, strategies and plans governing each sector of activity of the economy. Recommendations formulated take into account the changing structure of the economy as well as the challenges facing the island as a result of globalisation for example reduction in sugar prices on the world market, dismantling of the Multi-Fibre Agreement and rising oil prices on the international market.
Morocco: The NSSD process entails revising/updating existing policies, strategies and plans to incorporate key characteristics of NSSD, as well as developing a separate strategy document. The NSSD will be developed in the form of a document, which contains the sectorial orientations that will be used to update the existing policies, strategies or plans.
South Africa: The NSSD is not understood to be a new 'super policy' but rather a framework that builds on existing programmes and strategies. The NSSD will strengthen existing planning frameworks by lengthening the time horizon, and specifically by identifying long-term trends that may influence (positively or negatively) the intended development outcomes.

Source: Economic Commission for Africa (2010:9)

The participating countries in Table 5.2-2 consider that NSSD has been adequately addressed in existing planning frameworks, in varying degrees. The participating countries have put in place M&E mechanisms to track implementation progress and have recognised the need to link the different national planning frameworks such as National Long-Term Visions (NLTVs), Poverty Reduction Strategy (PRSs), NDPs and (MDGs and are ensuring complementarities among the frameworks and have considered the frameworks as constituting the NSSDs.

5.2.1 Economic Pillar

Africa is changing, with an overall growth rate rebounded at 5% in 2012, and projected to remain strong at 4.8% in 2013 and 5.1% in 2014 (UNECA, 2013:6). However the pattern of growth, about 5.8 per cent over the period 2002–2008 in the African region may not be sustainable, because it is based on the use of non-renewable or exhaustible natural resources and has not been associated with significant improvements in employment (African Development Bank, 2011). Sub-Saharan Africa, in particular, has continued with an impressive growth rate of close to 5% in 2012 (with similar projections for the next two years), with only emerging Asia registering higher growth (WEF, 2013:42). Sub-Saharan Africa reflects one of significant regional variations in the GCI, ranging from Mauritius (overtaking South Africa and coming in at 45th in year 2013/2014) to the lowest ranked Chad at 148th.

Out of 148 surveyed in the 2013/14 WEF's Global Competitiveness Index, Mauritius climbed nine places to 45th to rank as Africa's competitiveness leader for the first time, followed by South Africa (53rd, down by 1), Rwanda (66th, up by 3), Botswana (74th, up by 5), Morocco (77th, down by 7), Seychelles (80th, down by 4), Tunisia (83rd, first survey), Namibia (90th, up by 2), Zambia (93rd, up by 9), Kenya (96th, up by 10), and Algeria (100th, up by 10) (WEF, 2013:42-46). The Middle East and North African region has been affected by political turbulence that has impacted individual countries' competitiveness. At the same time, some small, energy-rich economies in the region performed well in the 2013 rankings (WEF, 2013:40).

Technological uptake continues to remain weak, with only three economies (South Africa, Mauritius, and Seychelles) featuring in the top half of the overall GCI rankings on the technological pillar (WEF, 2013:42). A major constraint on the projected growth can be attributed to "profound infrastructure deficit" in the African region (WEF, 2013:42). A lack of strong capabilities has limited many African countries from technological leapfrogging for example (Lall & Petrobelli, 2002; Oyelaran-Oyeyinka, 2006). From this research perspective, SST within the African region can be used to accelerate and leapfrog the transfer, adoption and adaptation of relevant technologies. Most of the LDCs in Africa are wedged in the conflict trap of countries prone to wars and coups such as Angola, Mozambique and Zimbabwe. The natural resources trap, is another form of democracy malfunction facing Malawi, Zambia and Zimbabwe. Lesotho, Swaziland, Botswana, Zimbabwe, Malawi, Zambia are some of the countries facing the landlocked trap, which is accelerated by the bad governance trap and having conflict-torn neighbours (Collier, 2007:7-37). The LCDs are 'trapped beyond control', asserts Collier (2007:37) and the only way out is through external subsidies or development assistance and trade preferences. However, Bauer

(2000:44) disagrees challenging that "…if external subsidies were indispensable for economic advance, mankind would still be living in the Old Stone Age".

5.2.2 Social Equity Pillar

According to Ikejiaku (2008:5), a major stumbling block to Africa's social development has been the external debt crisis. The stronger economic performance in the African region since 2000 has contributed to some progress towards the MDGs. However, the economic pace is further behind for achieving the goals by 2015, which includes reducing poverty, gender inequality, addressing HIV/AIDS pandemic and child and maternal mortality, and improving access to sanitation (UNECA, 2013:7-9). With the exception of Mauritius and Seychelles, Sub-Saharan Africa continues to underperform significantly in providing health and basic education. Higher education and training also need to be further developed in the sub-Saharan (WEF, 2013:42).

5.2.3 Environmental Pillar

Within the African region, innovation in the case of SST should be oriented to improving resource productivity, mitigating environmental impacts, decoupling and promoting a more SD pathway (Berkhout, Angel & Wieczorek, 2009). One major initiative for promoting decoupling with SST in Africa is the African 10-year Framework of Programmes on Sustainable Consumption and Production (UNEP, 2008). In the 10-year Framework members have agreed to implement several sustainable consumption and production initiatives that can promote resource and impact decoupling such as the creation of regional eco-labelling mechanisms. Figure 5.2.3-1 is a suggested cycle for promoting relative decoupling in Africa.

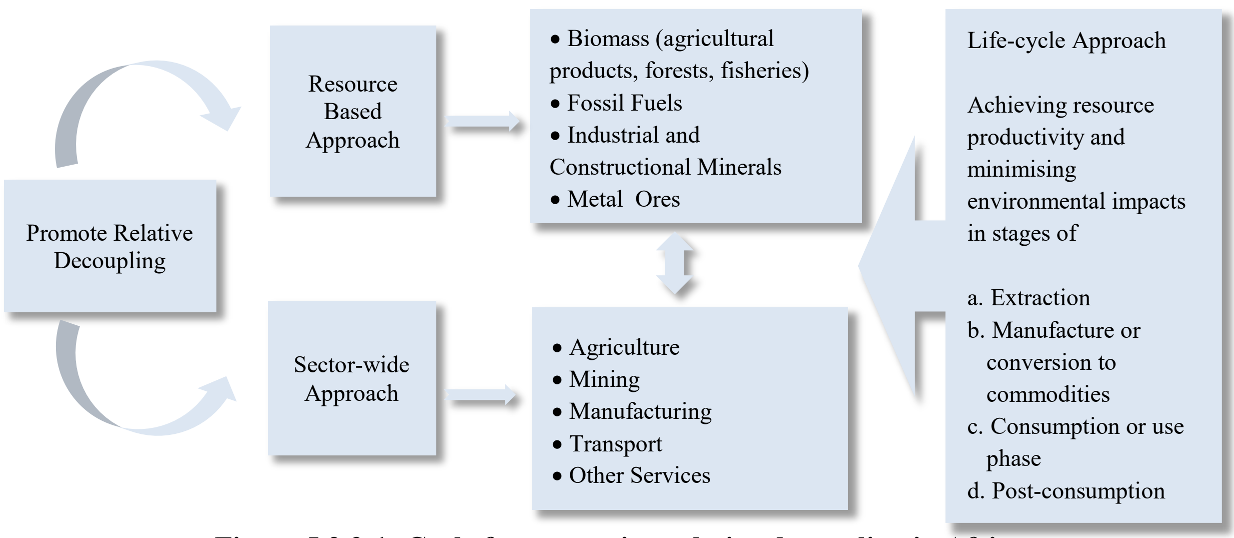


Figure 5.2.3-1: Cycle for promoting relative decoupling in Africa
Source: UNCTAD (2012:34)

Figure 5.2.3-1 can be used during the NSSD process of the African countries SD. Therefore, environmental protective measures should be pursued regardless of economic growth patterns, business cycles and innovation policy priorities. The specific policy framework and required instruments for decoupling and recoupling are still at early stages at the international policy debates (UNEP, 2011a). However, according to Lafferty et al. (2005:228), the process will require arriving at four types of environment innovation, namely: environmental protection, ecological communalism, ecological modernisation, and SD.

Bangladesh, Brazil, China, India, and Nigeria are among some of the most polluted areas on the planet (WEF, 2013:66). UNCTAD (2012:34-62) also observes that fossil fuels are the dominant material export and import of Africa. The level of domestic material consumption (DMC) per capita in Africa has decreased slightly from 5.6 tons per capita in 1980 to 5.3 tons per capita in 2008, which accounts for only 7.2 per cent of global material consumption. Material productivity in Africa is the lowest for any region in the world. Energy use in Africa is low and has been increasing much less rapidly than material use. Africa has contributed the least to global greenhouse gas emissions (GHG), but is the region most affected by climate change as increasing climate variability is already affecting crops, livestock, water sources, land, forest and biodiversity. Over the past 50 years, human activities to meet rapidly growing demands for food, fresh water, fibre, fuel and timber have extensively changed ecosystems. The low level of resource use in Africa reflects the very low levels of consumption, which allows for Africa to concentrate on relative rather than absolute decoupling (UNCTAD, 2012:34-62).

The human impact on natural ecosystems in Africa is generally low, but increasing at a rapid rate. With regard to land degradation and deforestation 65 per cent of Africa’s agricultural land, 31 per cent of its pasture lands, and 19 per cent of its forests and woodlands are degraded (UNEP, 2008). Africa’s has a high rate of deforestation, with two thirds of the land being either desert or dry lands. UNEP (2008) estimates that over 120 plant species in the African region are extinct, and that about 1,771 are under threat. Land use processes are found to be largely inefficient over large parts of Africa (UNEP, 2008).

The adoption and application of environmental productivity-enhancing technologies can be achieved through implementation of policies for raising land productivity and acquisition of foreign technologies policies (Forum for Agricultural Research for Africa, 2006).

5.2.4 Trade and Investment

Trade and investment are two sides of the same coin. However, little has been written on intra-African investment, which could be due to the fact that, until around 2000, the flows of intra-African investment had been negligible. Africa has also traditionally relied on foreign investments from outside the continent (UNCTAD, 2009:58-60). Fink and Jansen (2007) highlight the importance of investing in an efficient services infrastructure such as telecommunications, finance, logistics or professional services to draw on multinational networks and increase competitiveness. Resource rent is an example of an investment strategy that can play a significant role in financing SST in Africa (Jedwab, 2012). However, poor management of resource rent (such as mining rights) has often exacerbated economic instability, social conflicts and environmental problems in the region. African governments face the challenge of managing and making productive use of resource rent for SD. The Hartwick rule recommends investing resource rent in reproducible (physical, human or financial) capital by creating a special fund (Hartwick, 1977:973-974). The Extractive Industries Transparency Initiative (EITI) can also play a role in enhancing domestic accountability in managing rent funds and investments (UNCTAD, 2012:80). So far, 20 countries in the African region have joined the Initiative.

Trade occupies a special place in the discourse on economic integration offering the benefits of “trade creation” and “trade diversion” (Viner, 1950; Corden, 1972). The NEPAD promotes intra-African trade and investments. The development of the theory of regionalism (that is union theory) has been dominated by trade considerations. However, theory alone cannot be applied to fully explain and predict the pattern of intra-African trade (UNCTAD, 2009:17-18). An empirical investigation and analysis is needed to comprehend the determinants, the level, composition and direction of intra-African trade (UNCTAD, 2009:17). A foundation of the theory of regionalism theory was laid by Viner (1950) who argued that regionalism could result in “trade creation” and “trade diversion”. In Africa, development integration within the African region includes COMESA, ECOWAS, SADC and African Growth and Opportunity Act (AGOA) which, since 2008, has planned to merge to form a free trade area. The UNCTAD (2009:15) notes that many regional integration initiatives were over-ambitious, resulting in overlapping memberships and conflicting mandates that sometimes were often unclear.

Africa spends more than 10 times on imports of capital goods than earning in exports of similar goods. The implication is that Africa is not investing heavily in acquisition, use and generation of knowledge and is not attracting significant R&D intensive FDI (Hupe and Hill, 2006:18; UNCTAD, 2005; VTT, 2010; Chavula & Konde, 2011). Trade deficits and falling per capita growth continue to pose significant public policy and management challenges in the diversified (non-oil) economies (Economic and Social Commission for Western Asia, 2004).

Some scholars, for example, Schiff (1997), World Bank (2000) and Longo and Sekkat (2004) dispute the economic benefits of regional trading arrangements in developing regions, and Africa, in particular. Using the gravity model and a sample of 41 sub-Saharan African countries, Longo and Sekkat 2004 (1311-1318) undertook research which suggested that overall, trading blocs in Africa have not been able to positively affect the flows of trade in a significant way. Fontagné, Pajot and Pasteels (2002:117–131), however, caution the lack of econometric evidence should not be interpreted as meaning that regionalism in Africa cannot or has not had a positive effect on the flow of trade. The lack of evidence could be due to several factors, such as heterogeneity of the samples used in the research and analysis estimation (Fontagné et al., 2002).

Domestic investment growth in Africa was remarkable during 2000 and 2007 (UNCTAD, 2008). The growth of the mobile telecommunication industry in Africa was led by firms that were born on the continent. Some of the leading firms, such as Vodacom, MTN, Orascom, were all headquartered on African soil while CelTel (now Airtel) had mainly African investors (Kelly, 2004). In Ethiopia and Kenya, private colleges and universities are starting to rival those run by the government at least in terms of number of establishments. However, in terms of patent applications, Africa was the only region where patent applications have fallen between 1990 and 2008 (UNECA, 2012).

In the African region, FDI can bring large benefits to a developing host country economy (World Bank, 2008; Wade, 2010:154). Between 2000 and 2004 Angola, Equatorial Guinea and Nigeria accounted for over 50% of inward FDI, mainly due to demand in oil resources (UNCTAD, 2008). However, FDI in LDC have continued to remain marginal. First, FDI is highly concentrated in a small number of LDC (Roberts, Wade, Lall, Wood, 2003; Wade, 2010:153). Second, Moran (2006) ignores evidence on the harmful effects of FDI in LDC such as Latin America, where foreign firms have dominated the most dynamic manufacturing sectors since inception (Ciccone & Matsuyama, 1996; Wade, 2010:153).

Intra-African trade has been slow owing to similarity in production structures and the consumers' preference for cheaper products such as those from China (Dinka & Kennes, 2007). High costs due to poor hard and soft infrastructure (Limao & Venables, 2001); political tensions and conflicts also had a significant negative effect on regional trade (Longo & Sekkat, 2004). Challenges associated with both soft and hard infrastructures are problems related to implementation and basic design deficiency (UNCTAD, 2009:14). Other reasons for slow intra-African trade include the lack of transparency, unpredictability of trade, rigid policy and regulatory environment, lack of adequate transport and communication infrastructure, additional challenges faced by landlocked countries, bureaucratic and physical hindrances such as high road charges, transit fees and administrative delays at borders and port, lack of skilled labour and weak economic links and contacts among investors within the region (Longo & Sekkat, 2004; Ndikumana & Verick, 2008; UNCTAD, 2009:44-45). Africa's trade with the rest of the world has increased much faster than intra-African trade, an indication of the growing importance of Africa's new trade partners (UNCTAD, 2009:23). Whereas intra-African trade increased by 13.64 per cent per year, on average, between 1999 and 2006, the average yearly increases in Africa's trade with the U.S.A was 27.57 per cent, while trade with China increased at a yearly rate of 60.85 per cent over the same period. The next section reviews literature with respect to innovation policy and governance in the Africa region.

5.3 INNOVATION POLICY AND GOVERNANCE IN AFRICA

One of the fundamental problems facing many LDC can be attributed to the lack of having an explicit innovation strategy in place. The available NSI-related policies are inconsistent and disconnected. Disregarding the role of the informal sector and traditional sectors have also produced misleading, asymmetrical or ineffective innovation strategies. Yet, the informal sector represents three-quarter of non-agricultural employment and over 40% of the gross national product (GNP) of many African countries. According to Metcalfe and Ramlogan (2006:375-378;2008:445-447), the overall vitality of the NSI will require more in-depth literature on the role of the informal sector as well as linkages between the formal and informal sector. The potential to engage in knowledge conversion for the benefit of the informal sector low-income earners has been exploited by, for example, Hughes and Lonie, (2007) and Wamae (2009). Hughes and Lonie, (2007) and Wamae (2009) explored knowledge conversion at the Equity Bank, a locally owned bank in Kenya and M-PESA a mobile technology money transfer innovation, have both successfully offered banking services to the 'poor' unbanked population who were previously locked out of conventional banks (Hughes & Lonie, 2007:67-77; Wamae, 2009:221-214).

Clapham (2001:66-68) and Herbst (2000:11) are pessimistic of an effective innovation policy in the African continent owing to many African countries being led by former liberation movements or authoritarian, single-party governments. Mkandawire (2001) argues that the trouble with the good governance paradigm is that it comes embedded in neo-liberal policy of which African state capacities have been stripped. Leading to what Chabal and Daloz (1999:142) term as

"…unrealistic expectations in terms of the development potential of a modern independent Africa". A paradigm in this research context is about the logic, the values, the principles, and the general path of movement, a theoretical structure of experience whose practical operation varies depending on the historical circumstances of each country (Ake, 2001: 124). Some theorists have argued that Africa needs to formulate its own development paradigm that considers the unique socio-economic, political and environmental character of the continent (Meyer, Theron & Van Rooyen 1995:7). A successful innovation policy will require a clear vision to ensure a transparent regulatory and incentive structure and define possible technological trajectories in line with the innovation objectives.

NEPAD has set out a "Consolidated S&T Plan of Action" (African Union–New Partnership for Africa's Development (AU–NEPAD), 2010). The plan seeks to improve the quality of STI policies of African countries through processes that promote sharing of experiences and policy learning (Kahn, 2008:164; AU-NEPAD, 2010) and rests on four pillars - capacity building, knowledge production, technology and innovation. This research shares similar views with Metcalfe and Ramlogan (2006:375) that building effective NSIs in the African region will require identifying bottlenecks and 'abnormalities', improving knowledge flows and strengthening linkages within and across the systems. To this end, the next section reviews of the African region NSI: main features and performance and the research and knowledge systems.

5.4 AFRICAN NSI: MAIN FEATURES AND PERFORMANCE

This sub-section examines literature on the African region NSI for SD through research. Historical perspectives to innovation and industrial development indicate that during the 1970s many African countries established national research councils and R&D centres. The innovation and industrial development was partly driven by the Conference of Cabinet Ministers responsible for the Application of Science and Technology (CASTAFRICA I) held in Dakar, Senegal, in January 1974. The number of African countries with S&T promotion bodies increased from 4 to 28 between 1974 and 1987. Also, several R&D institutions specialising in natural sciences, agricultural, medical, nuclear, industrial and environmental research increased rapidly on the region.

Policies relating to STI in many African governments have been encouraged by NEPAD. The UNCTAD (2012:82) notes that STI policies should not simply adopt a science-push approach to innovation, but rather focus on building an entire NSI. A weak and fragmented NSI in LDC is a major challenge as observed by Knutsen (2004:16-17). Therefore, it may be argued that integration is paramount for addressing the problem of fragmented African NSIs. The next section reviews research and knowledge systems within the African region.

5.5 AFRICAN RESEARCH AND KNOWLEDGE SYSTEMS

The sub-section represents the African regional perspective research and knowledge management system. The HEIs fulfil a crucial role in respect of the resolution of the complex 'wicked' challenges that face the African region. The emergence of a knowledge-based economy and globalisation, for example the BRICs, are restructuring the dynamics of innovation in LDC, which targets low-income earners previously not considered. Knowledge diffusion in developing economies is an essential aspect of innovation, which involves international knowledge spill-overs, foreign R&D stocks with bilateral import shares, the purchase of capital goods and services, sources such as scientific publications, attendance at trade fairs, and the acquisition of tacit knowledge through collaboration (Coe & Helpman, 1995; Keller 2004; Lumenga-Neso, Olarreaga & Schiff, 2005; OECD/Eurostat 2005:84; Henry, Kneller & Milner, 2009; Kokko, 2010:115), imports from R&D-intensive countries prompting reverse engineering (Mansfield, Schwartz & Wagner, 1981; Zander, 1991). However, SA DST Ministerial Review Committee, (2012:83) notes that the ways in which knowledge diffusion and spill-overs have operated historically, and now, are still unknown.

Innovation policies that pursue the acquisition of international knowledge have traditionally focused on reinforcing the reliance on foreign investment, joint ventures and imports of capital goods (Ernst & Kim, 2002:1419-1424). It may be highlighted that the importance of systematic outward-oriented trade and investment policies in education and training (a set critical of absorptive competences), S&T, and R&D as important components of maximising knowledge flows in LDC. Lundvall and Borrás (1998:35) emphasise the concept of a "learning economy" as critical for economic development rather than relying on existing knowledge stock (Lundvall & Borrás, 1998:35). Also important is a country's significant level of absorptive capacity, the ability to assimilate and internalise the disseminated knowledge for diffusion of innovation (Cohen & Levinthal, 1990:136,148, Liu & White, 2001:1138, Narula & Marin, 2005). Developing countries, to a great extent are dependent on the knowledge created in the larger OECD countries (Kokko, 2010:113), which still remains relatively isolated from global innovation dynamics (Hobday, 2003). The local selection, assimilation and adaptation of knowledge are central in applying and re-inventing international knowledge locally.

According to the World News Global (2013), the emigration rates of highly-educated citizens to OECD member countries are a major social problem for the developing world, with a negative effect on African research and knowledge systems. The proportion of highly educated people from LDC residing in OECD countries is significant for Jamaica (46%), Tonga (46%), Zimbabwe (43%), Mauritius (41%), the Republic of Congo (36%), Belize (34%) and Fiji (31%).

South Africa was an influential centre for intra-African research collaboration before the 2000 as illustrated in Figure 5.5-1. However, during 2004-2008, key focal points included Senegal, Cameroon, Nigeria, Uganda and Morocco, as shown in Figure 5.5-2 (Royal Society, 2011:52-53). Networks and universities in South Africa, Nigeria, Egypt, Kenya, and Burkina Faso indicated poor intra-African collaboration (Nwaka, Ilunga, Da Silva & Verde, 2010:4).

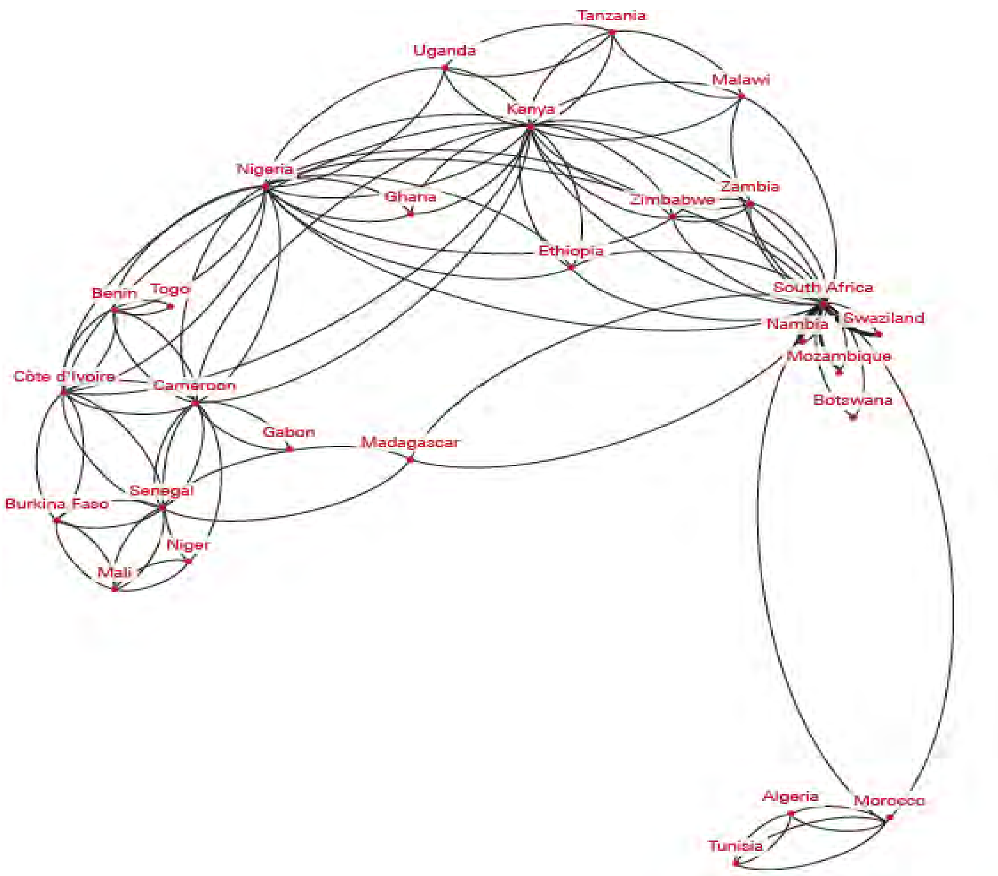


Figure 5.5-1: Collaboration between African countries169 during 1996-2000
(Source: Royal Society, 2011:52-53)

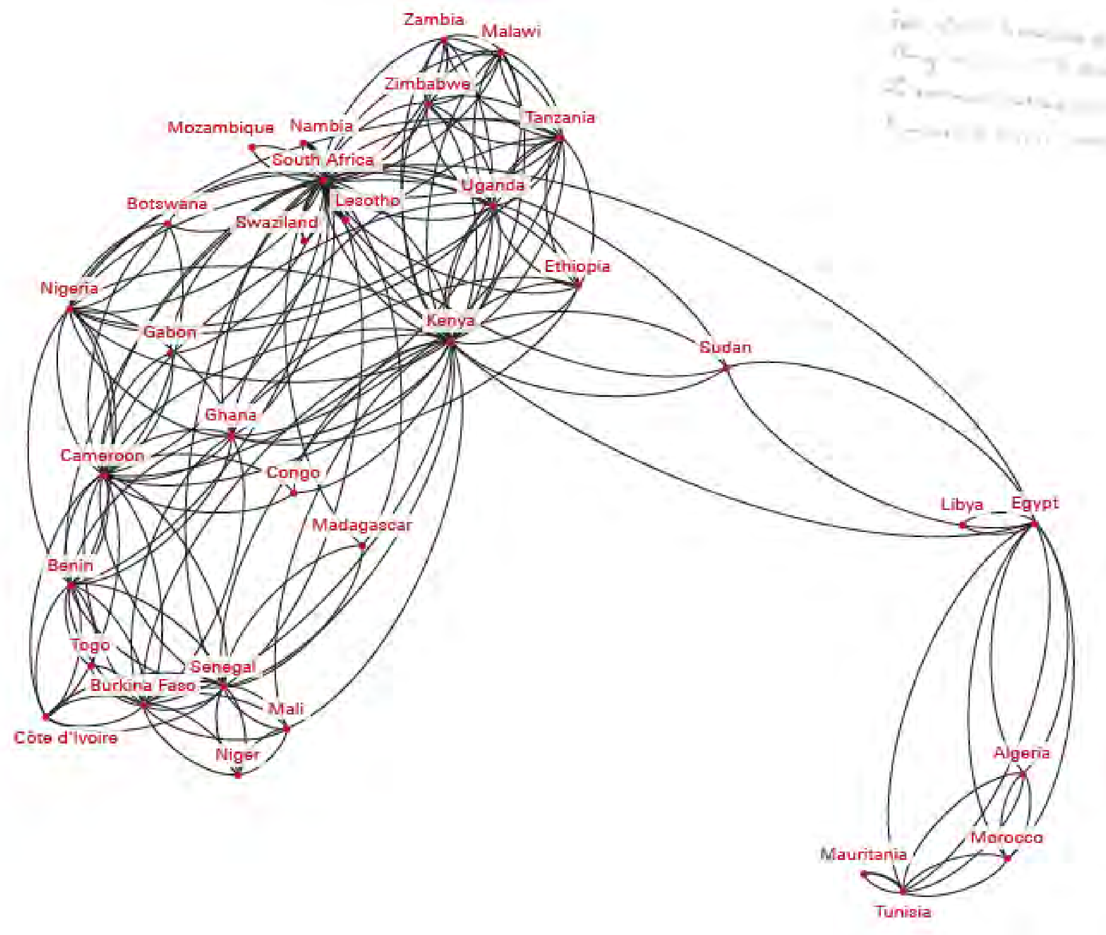


Figure 5.5-2: Collaboration between African countries169 during 2004-2008
(Source: Royal Society, 2011:52-53)

The strengthening of the network in Figure 5.5-1 and Figure 5.5-2 coincided with increased overall domestic research production (South Africa and Egypt both growing by 43% and Sudan by 89% between the periods 1999 to 2003 and 2004 to 2008). In Egypt, overall investment in science jumped from US$403 million in 1996 to $911 million in 2007, and in South Africa investment more than doubled over the same period (UNESCO, 2010:1; Royal Society, 2011:54).

Beyond regional collaboration, there is also increasing 'south–south' collaboration, for example, between India, Brazil and South Africa recently joined forces through the science and research 'IBSA initiative' (UNDP Millennium Project, 2005). The China–Africa S&T partnership programme (CASTEP) was launched in 2009, with the Chinese partners providing funding for African scientists to study in China, as well as funding for research equipment on return home. Collaboration can enhance the quality of research work in terms of citation, increase the effectiveness of the research and overcome logistical obstacles by sharing costs, tasks and expertise (Royal Society, 2011:59).

The development of SST in the African region will require a strong and committed research community and an active network of collaborating research institutions. However, a study that analysed journals indexed by Thomson Reuters between 2007 and 2011 found that Africa's heavy dependency on international scientific collaboration may be stifling research individualism and affecting the continent's research evolution and priorities. Papers co-authored by African academics with international partners grew by 66% in five years (Royal Society, 2011:61). The next section is a literature review on the African region is development of the innovation indicators for SD through research in the NSI.

5.6 AFRICAN INNOVATION INDICATORS

The African STI Indicators (ASTII) initiative by NEPAD (2010: xvii) states that "Africa needs STI indicators to measure the significance of STI in its development". The ASTII initiative addresses the lack of evidence-based policy processes and better understanding of, and improvement in the state of STI in the African region (NEPAD, 2010: xviii).

The R&D surveys conducted by the ASTII NEPAD (2010: xx) identified two indicators relevant to the African region NSI, namely: the GDP expenditure on R&D by source of funds and sector of performance; and (ii) R&D personnel by level of formal qualification and occupation, gender, headcount and full-time equivalent, as well as researchers by gender and field of study/research. Table 5.6-1 presents some of the indicators of NSI performance.

Indicators in Table 5.6-1 can be used in the African region to analyse (i) input indicators, (ii) output indicators, (iii) flows, and (iv) ratios and indexes. African countries set a target of spending 1% of GDP on R&D in 1980 (Organisation of African Unity, 1980) and reinforced commitment in 2006 (NEPAD, 2010:37).

During the AU general meeting of 2007 African leaders reiterated and agreed to reach the 1% target by 2010 (UNESCO Institute for Statistics, 2010:1). South Africa was the only sub-Saharan country that is close, spending 0.92% in the 2008 to 2009 financial year (SA DST, 2010b:2). However, by 2007, Sub-Saharan African countries still spent an average of just 0.5% of GDP on S&T (UNESCO Institute for Statistics, 2010:1). According to the ASTII survey results three countries (Malawi, Uganda and South Africa) scored R&D intensity above 1%, with the other countries ranging between 0.20% and 0.48%. The ASTII survey further showed that government is the most important funding source of R&D activities in participating countries.

Table 5.6-1: Indicators of NSI performance

INDICATORS (BENCHMARKS)	
Input indicators	• R&D Expenditures (at both micro and macro level) • R&D Personnel • Number of institutions conducting R&D • Expenditures in higher education
Output indicators	• Production of technology-intensive goods • Scientific publications • Citations to patents and publications • Number of Innovations • Exports of technologically-intensive goods and services • University graduates in S&E • Personnel flows among organisations
Flows	<u>Knowledge flows, including</u> • Technology transfer • Technological alliances • Machinery diffusion <u>Financial flows, including</u> • Venture capital for new high-technology firms • Government subsidies for R&D • Regulatory flows • Intellectual property legislation • legislation on standards • Anti-trust and cooperative rules and laws <u>Human flows</u> • University graduates supply and demand by discipline and institution
Ratios and indexes	GERD/GDP
At NSI level	• Revealed technological advantages • Input/output macroeconomic ratios • Trade balances on high-technology goods and services
At the organisation level	• Input/output microeconomic ratios: patents and/or publication and /or innovation per unit of resource used (that is million dollar expenditure or per full-time researcher)

Source: Niosi (2002:299)

Table 5.6-2 source ASTII of NEPAD, (2010:37) shows some of the results for the countries in the ASTII R&D survey (2007/2008) initiative that have collected data on GERD. In order to allow for inter-country and international comparisons, the GERD data are translated into the US purchasing power parity (PPP) dollars.

Table 5.6-2 indicates that South Africa spends 8.5 times more on R&D than Africa’s most populous country, Nigeria which, on a per capita basis, the gap is 26 times. However, the Nigerian survey did not cover the business enterprise sector, so the gap is probably smaller. Malawi and Uganda have an R&D density (GERD/GDP ratio) of over 1% (1.70% and 1.10%, respectively).

Table 5.6-2: Gross domestic expenditure on R&D (GERD) (2007/08)

GROSS DOMESTIC EXPENDITURE ON R&D (GERD) (2007/08)				
	Year	GERD per million PPP$	GERD per capita PPP$	GERD as % of GDP
Gabon	2008	78.7	58.3	0.47
Ghana	2007	120.1	5.0	0.38
Kenya	2007	277.8	7.4	0.48
Malawi	2007	180.1	12.9	1.70
Mali	2007	37.4	3.0	0.28
Mozambique	2007	42.9	2.0	0.25
Nigeria	2007	583.2	3.9	0.20
Senegal	2008	99.0	8.0	0.48
South Africa	2007	4 976.6	102.4	1.05
Tanzania	2007	234.6	5.8	0.48
Uganda	2007	359.8	11.6	1.10
Zambia	2008	55.3	4.6	0.37
Caution is urged in interpreting the data. Some countries have not covered all sectors				

Source: ASTII NEPAD (2010:37)

Other African countries have a GERD/GDP ratio that range from 0.20% to 0.48% as shown in Figure 5.6-1. Malawi's research funding can be attributed to donor funding for R&D activities and international research institutions, including the Consultative Groups on International Agricultural Research (CGIAR) centres, Welcome Trust, Global AIDS Research Initiative many of which have relocated to Malawi (ASTII R&D survey (2007/2008) initiative of the NEPAD (2010:37).

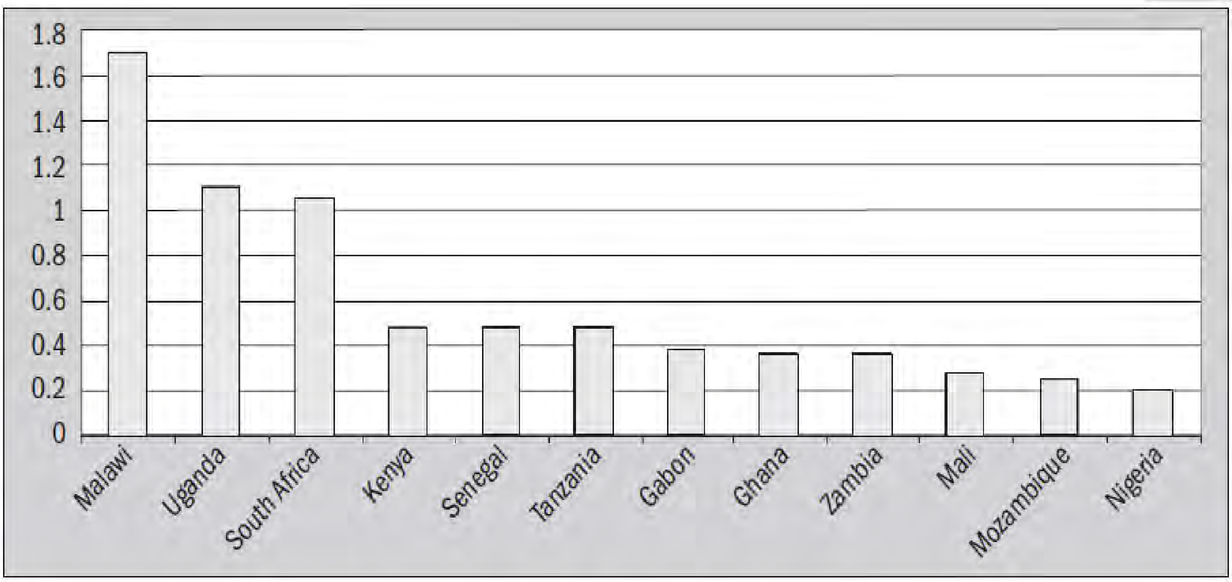


Figure 5.6-1: GERD as a percentage of GDP ASTII R&D survey (2007/2008)
Source: ASTII NEPAD (2010:38)

In Uganda, in addition to providing resources for public goods and services, the government has also provided funds for scientific research, especially research in banana development and fruit-juice processing and malaria. In addition, the Ugandan government negotiated a five-year US$30 million project in terms of the Millennium Science Initiative funded by the World Bank to support research, education and training in S&T with linkages to industry. Some of the funds were geared towards strengthening the Uganda Industrial Research Institute (UIRI) and the Uganda National Council for S&T (ASTII initiative NEPAD, 2010:38).

Nigeria is ranked 120th for the 2013/2014 WEF (2013:44) index with a relatively large market size (32nd), which has the potential for attracting investment. Nigeria also benefits from an efficient labour market and the financial market has been recovering gradually from the 2009 crisis. However, efforts need to be taken to diversify the Nigerian economy into the non-oil sector and increase long-term competitiveness. Nigerian institutions remain weak (129th) with insufficiently protected property rights, high corruption and undue influence. The security situation is on a downward trend to 142nd. Additionally, Nigeria must continue to upgrade infrastructure (135th) as well as improve health and primary education (146th). Furthermore, the country is not harnessing the latest technologies for productivity enhancements, as demonstrated by low rates of ICT penetration (WEF, 2013:44). To this end, the next section undertakes a review of public administration and public policy in the African region.

5.7 PUBLIC ADMINISTRATION AND PUBLIC POLICY IN AFRICA

The section explores the public administration and public policies in the African region NSIs. Several international organisations have played significant roles in the development of S&T and public policies and administration among African countries, including UNESCO, UNCTAD, IDRC, and the Swedish Agency for Research Co-operation with Developing Countries (SAREC). However, the international organisations initiatives have mostly focused on the development of S&T with minimal emphasis on the role of public policies and administration, which would increase learning and innovation performance in Africa (Srininvas and Sutz, 2008:129-140; Di Maio, 2008:17; Chavula & Konde, 2011:5). Scholars such as Lundvall, Interakummerd and Vang (2006), Srininvas and Sutz (2008) and Juma and Yee-Cheong (2005) have also criticised the multilateral institutions' interventions and harmonisation activities owing to the lack of consistency with the overall developing economies institutional frameworks.

The ‘wicked’ challenges are some of the issues that affect the development of public administration and policy in the Africa region. Access to the basic necessities (food, potable water, housing, fuel and energy) is highly restricted in Africa. Life expectancy in the region declined from 49 years in 1999 to 46 years in 2001 owing largely to the impact of HIV/AIDS, malaria and tuberculosis (United Nations, 2005:4-5). However, life expectancy in Africa was projected to rise to 51.3 years by the end of 2010 and to reach 69.5 years by 2045. Among the plausible explanations for the lacklustre performance of the developing regions’ human development front are weaknesses in governance and public administration, failure to reflect poverty concerns in budget allocations and the exclusion of the poor from decision-making (Economic and Social Commission for Western Asia, 2004). To surmount the ‘wicked’ challenges within the Africa region will require promoting public administration and public policies for SD through research within the NSIs.

A number of priorities in public administration reform in Africa include promoting democratisation and decentralisation; developing legal and institutional frameworks and economic governance systems; implementing ethics and anti-corruption strategies; improving resource mobilisation and financial management systems; and tapping the potential of e-government (United Nations, 2005:12). Edquist et al. (2009:17) observe that innovation policy objectives are formulated in a political process.

According to the United Nations (2012:3), efforts to improve public administration in Africa may include more joint research directed at informed policy formulation; collaborative programming among agencies; increased interactions and peer learning in the development of South-South programmes, strategies and projects; and increased systematisation of South-South cooperation in the “delivering as one” pilot countries. The African Charter on Democracy, Elections and Governance has now come into force, representing a major commitment to improving and monitoring governance in Africa (UNECA, 2013:6-7). The next section is a review of NSIs in other developing regions.

5.8 NATIONAL SYSTEM OF INNOVATION AND SUSTAINABLE DEVELOPMENT TRENDS IN OTHER DEVELOPING REGIONS

According to the Sussex Manifesto of (1970) cited in Singer et al. (1970), LDC were estimated to account for only 2% of the global gross expenditure on R&D. By 2000, the figure had risen to 21%. Asia represents almost two-thirds of developing country GERD in 2007, and indication that

Asia is contributing in the generation and conversion of knowledge to value (Ely & Bell, 2009:34). The LDCs have not shown signs of research growth. Cambodia produced only seven articles in 1996, but increased to 114 by 2008. During 2008, both Uganda and Peru increased outputs four-fold, albeit from low bases (Uganda from 116 to 477 papers, Peru from 153 to 600) (STEPS Centre, 2010).

According to research conducted by Nwaka et al. (2010) on health, S&T between 2004 and 2008, 77% of African biomedical research papers were produced with international partners, while only 5% of the papers were the result of intra-African collaborations. The links between BRIC countries have grown, however pale in comparison with the volume of collaboration between the individual countries with the G7 partners. Nevertheless, the BRIC partnerships trend may prove to be a significant factor in the dynamics of global science in the future (Royal Society, 2011:52-53).

In Asia and the Pacific, the revitalisation of public administration has to address enormous poverty alleviation and human development challenges. Asia and the Pacific are faced with enormous challenges in the area of human development, of 3.4 billion total population, 1.2 billion people are living in extreme poverty (living on less than one U.S.A dollar per day (United Nations, 2005:7).

During 2000-2010 the Chinese economy grew at an averaging 9.6 per cent annually per capita and does not show signs of decelerating. State-owned enterprises accounted for about 44 per cent (World Bank, 2010) and the financial system is state-controlled, with the government owning the four largest banks. China's current involvement in Africa has diversified Africa's economic options, with a diminishing export of high-technology products from the Western countries. Between 1999 and 2005, China established itself as the world's largest exporter of high-technology manufacturing products, which grew in market share in exports from 8% to 19% (NSB, 2008). The Chinese institutional framework is improving slightly (47th), but weaknesses, including corruption (68th), security issues (75th), low levels of accountability (82nd) and ethical standards (54th) among businesses remain. The Chinese financial market (54th) is undermined by the relative fragility of the banking sector, by technological adoption by both the firms (86th) and by the population at large (79th), which remains very low. The efficiency of its goods market (61st) is undermined by various barriers to entry and investment rules, which greatly limit competition (WEF, 2013:34). China's policy towards foreign investment is opposed to worldwide reforms, including the rules of the WTO (Weisbrot & Ray, 2011). Although China performs well in health and basic education (40th), the assessment is more negative when it comes to higher education (70th) because of China's low tertiary education enrolment, the average quality of teaching and an apparent disconnect between educational content and business needs (54th). China's innovation capacity has been improving recently, but much remains to be done for the country to become an innovation powerhouse (WEF, 2013:34).

India, with more than 1.2 billion people represents the fourth largest economies in the world (Royal Society, 2011:19), which also had a fast-growing economy during the last 10 years. India's biggest growth acceleration was for the fiscal years 2003-2008, with per capita GDP growth averaging about 8.9 per cent annually for the period. Per capita growth fell with the world recession in 2008/2009 fiscal year to 6.7 per cent, but has rebounded to about 7.4 per cent for 2009/2010 (Weisbrot & Ray, 2011:15). India adopted a number of liberalising reforms beginning in 1991, including sharply reducing the peak tariff rate (from 300 to 110 per cent); the loosening of the Monopolies and Restrictive Trade Practices Act, which reduced barriers to entry; some privatisations, and liberalisation of foreign investment (Royal Society, 2011:19).

India's growth acceleration since 1991 demonstrates the success of the liberalising reforms. While some have argued that the acceleration post-1980 can be attributed to a government shift toward pro-business policies, which is not the same as pro-market policies (Rodrik & Subramanian, 2004). However, there has been a good deal of debate over how to interpret India's growth acceleration. Bhalla (2010) associates interpret India's accelerated growth with macroeconomic policy changes such as lower interest rates and real exchange rate depreciation, which are in the opposite direction of the neoliberal reforms. Rodrik (2008) characterises India's recent state as "an undervaluation of" around 60 per cent. From this research perspective, India can continue with the accelerated growth while being a net capital importer, which is one advantage that other fast-growing LDC do not have.

The Malaysian economy has both features of commodity producer and high-technology factory producing items. Malaysia's policies are characterised by the Bumiputera affirmative action policy, with the economy's positive export market performance taking place through authoritarian rule, government's subsidy and exploitation of cheap labour. In part driven by quota policies, Malaysia experiences brain drain and faces stagnation because the HEIs and research base have not been sufficiently developed. Having explored the African region NSI trends, the next section is the chapter summary.

5.9 SUMMARY

This chapter has examined trends in SD in the African regional context in terms of the business sectors (economic pillar), social equity and environmental sustainability pillars. A review of literature with respect to innovation policy and governance and the African region NSI: main features and performance was also conducted. Furthermore, the chapter also reviewed research and knowledge systems, explored the development of innovation indicators for SD through research in the NSI and undertook a review of public administration and public policy within the African region.

The chapter therefore added on to the importance of intra-African region NSI dialogue and by drawing out both context-specific and generic country experiences for NSI policy developments in South Africa. The chapter has identified a weak and fragmented NSI as a major challenge facing many LDC, which is exacerbated by the lack of an explicit innovation strategy. The chapter has further established that STI policies should not simply adopt a science-push approach to innovation, but rather focus on building an entire NSI. The emergence of a knowledge-based economy and globalisation such as the BRICs are restructuring the dynamics of innovation in LDC. The chapter has also shown that several international organisations have played significant roles in the development of S&T and public policies and administration among African countries However, the international organisations initiatives have mostly focused on the development of S&T with minimal emphasis on the role of public policies and administration, which would increase learning and innovation performance in Africa.

CHAPTER SIX

INTERNATIONAL NATIONAL SYSTEM OF INNOVATION AND SUSTAINABLE DEVELOPMENT TRENDS

6. INTERNATIONAL NATIONAL SYSTEM INNOVATION

The previous chapter examined the construct of SD through research in the NSI in the African region. This chapter undertakes literature review on the construct of SD through research in the NSI from an international perspective, which will be utilised in later chapters to draw out both context-specific and generic transferable country experiences that can inform policy developments in South Africa.

6.1 INTRODUCTION

Most of the literature review in this research topic has made use of international literature. As such this chapter briefly explores some specific international country experiences on the construct of SD through research in the NSI. The selected countries span a diversity of history, economic structure and national polities, especially with respect to regional autonomy. While bearing superficial resemblance to others, each country's NSI is unique to itself because each contains some generic elements. This chapter is organised as follows: section 6.2 provides a review of three pillars of international perspective sustainable developing trends, in terms of the economic pillar, social pillar and the environmental pillar. Section 6.3 entails a discussion of the innovation indicators for SD through research in the NSI from an international context. Section 6.4 presents a review of trends in international NSI: main features and performance. Section 6.5 undertakes a review of public administration and public policy from an international perspective. Section 6.6 is a discussion of trends in international research and knowledge systems. Section 6.7 presents the Chapter summary.

The trend in industrialised countries is towards the "internationalisation" of economic activities, which can be defined as "the wide set of processes and relationships that result when previously fairly separate national economies become increasingly interrelated and economically interdependent with one another in unprecedentedly high degree" (IDRC, 1993:12). Further, the IDRC (1993:12) notes that the process of internationalisation involves the exporting and importing goods and services, the outward flows of direct foreign investment, the flows of S&T, the trans-border data flows and the international movement of skilled personnel. In this research context, international refers to the exchange of experiences and the integration of inter-continental collaboration and cooperation networks among countries within the NSI. Having briefly introduced this chapter, the next section provides a review of three pillars of SD trends from an international perspective in terms of the economic pillar, social pillar and the environmental pillar.

6.2 INTERNATIONAL SUSTAINABLE DEVELOPING TRENDS

This section reviews the three pillars of SD, namely: the economic, social and environments from an international perspective. The global networks such as the G8, the G20, the EC, the Association of Southeast Asian Nations (ASEAN), and the African Union have elected to identify and address global concerns such as poverty alleviation, sustainability and diversity (STEPS Centre, 2010; Royal Society, 2011:36).

The OECD developed an innovation strategy in 2007, which serves as a means of addressing global challenges and evaluation of innovation polices along with country-specific analyses (OECD, 2010b:14). The OECD mission is to support world sustainable economic growth, boost employment, raise living standards, maintain financial stability, economic development and contribute to growth in world trade (OECD, 2013a). In 2009, the EU declared the innovation policy one of the seven ‘flagship initiatives’ of EU ‘2020 strategy’. The U.S.A government has placed the innovation policy at the centre of strategy for SD (economic and social) recovery (U.S.A Executive Office of the President, National Economic Council, Office of S&T Policy, 2009; The White House, Office of the press secretary, 2009).

6.2.1 Economic Pillar

In the list of the most competitive economies the WEF (2013:66) notes that Switzerland tops the overall rankings for the fifth year running, followed by Singapore and Finland, with Germany moving up two places into fourth overall, and the U.S.A reversing a four-year slide by climbing two places to fifth. Sweden, Hong Kong, the Netherlands, Japan and the UK complete the list of the top 10 most competitive economies.

South Africa, Australia, Norway and Brazil are three commodity-exporting countries, with the Australian system bearing a similar set of institutions the closest to South Africa. However, the Australian NSI is larger, and committed to a representative, transparent, high-level prioritisation and policy learning through institutionalised M&E and foresight. Norway’s economic performance has been consistently good for a long time and average real incomes are now among the highest in the world (OECD, 2008:7). Even excluding the high impact of hydrocarbon exports, Norwegian per capita incomes are high international comparisons (OECD, 2008:54). However, Norway "underperforms" against conventional S&T and innovation indicators despite the persistently high economic performance, hence the "Norwegian puzzle" or 'paradox' (Koch & Hauknes, 2007; OECD, 2008). Soete (2006:214) defines the European "paradox" as the "fact that contrary to economic theory and intuition, a strong scientific research base does not appear to go hand in hand with strong technological and economic performance, rather the contrary". The "puzzle" is particularly visible when R&D-based indicators are used to benchmark the Norwegian innovation system (OECD, 2008:54). Engineering capabilities and R&D may be one factor in the "Norwegian puzzle" because large firms such as Statoil and Telenor account for a relatively higher share of (especially "unrecorded") innovation than of R&D (OECD, 2008:94). SINTEF is the largest of the Norwegian research institutes, and plays a significant role in the search for one-off engineering solutions for exploitation of the North Sea oil and gas resources (OECD, 2008:126-127).

6.2.2 Social Equity Pillar

It would appear that the main social and environmental challenges facing Europe are similar to the Grand Challenges outlined in the South African policy documents such as the SA DST TYIP. Owing to the slow economic growth experienced during the 2009, the GDP fell by roughly 4% for both the EU and the Euro zone (European Commission, 2009). In 2009 unemployment rate across Europe was 9.8%, especially youth unemployment and generational worklessness (Eurostat, 2009). Global social challenges include smallpox, against which the World Health Organisation (WHO) launched an intensified plan to eradicate (Royal Society, 2011:74). Another is the 2004 tsunami, which resulted in loss of over 220,000 lives because there was no in-built warning system to alert people in sufficient time. An Indian Ocean tsunami warning system was finally set up for detecting natural hazards and providing early warnings (NERC, 2011).

According to the EC (2009), the EU Lisbon Agenda of 2002 is to create "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion". The Lisbon Strategy played an important role in stimulating economic growth and creating jobs across Europe (European Union & Young Foundation, 2010:7-9). However, Europe faces the issue of an ageing population. It is estimated that by 2020, 25% of the population will be over 60. The 80+ population is expected to double before 2050 - meaning a ratio of 2:1 of workers to retirees- leading to an increase of costs linked to pensions, social security, health and long-term care by 4-8% of GDP by 2025 (European Union & The Young Foundation, 2010:8). Challenges associated with social exclusion such as health care,

housing and education have also not been solved in Europe, which can be addressed through social innovation (Jouen, 2008).
During 2012, Sweden performed well both in terms of social and environmental sustainability, but at a lower level than other Nordic countries, especially on the social pillar due to the persistently high youth unemployment rate. Norway is the only other country besides Switzerland that attains very strong results in both environmental and social sustainability. Norway has a wide-ranging social protection and youth unemployment is below 10 per cent. Finland attains a similar performance to Norway, scoring well especially on the social dimension with a high level of social protection and universal access to healthcare. However, Finland has experienced relatively high youth unemployment of 20.3 per cent (WEF, 2013:67).

In comparison to the Nordic countries, during 2012 the U.S.A had somewhat better results for social than for environmental sustainability. However, the U.S.A social sustainability score is somewhat lower than that of other advanced economies because of high income inequality and relatively high youth unemployment (17.3 per cent). In the U.S.A during 2012 more than 16 per cent of the population lived in poverty compared to 14.3 per cent in 2009 (WEF, 2013:68).

Despite a relatively high level of income inequality, Japan has a relatively positive assessment in the 2012 social sustainability component, performing better than other economies due to low youth unemployment, a small informal economy and a sound social safety net (WEF, 2013:68). China has less positive sustainability competitiveness due to the low performance in environmental and social pillars measures. China does not report data related to youth unemployment or vulnerable employment resulting in low social performance. Additionally, income inequality is high in China (WEF, 2013:70). Brazil has a low performance in terms of social sustainability due to high income inequality and poor access to health and sanitation. Inefficient and expensive public transport, rising prices compared to the level of salaries and poor access to credit, combined with strong income disparities, also undermine Brazil's social sustainability (WEF, 2013:71). India's social sustainability performance is hindered by the growing income inequality, caused by the lack of access to basic sanitation, health services, low social safety net, a large informal sector and a high share of vulnerable employment (WEF, 2013:71).

6.2.3 Environmental Equity Pillar

In Europe, the Stern Review estimated that climate change could cost between 5% and 15% of global per-capita consumption (Stern, 2007). The German Institute for Economic Research estimated that annual climate related economic damages would reach €14 trillion by 2100 – or 6%-

8% of global economic output. Tackling the issue of climate change will require major changes: new sources of energy, new infrastructures, working patterns, methods of production and distribution, new forms of interaction, behaviours and beliefs (Nordhaus & Boyer, 2000).

In terms of the 2012 environmental sustainability, Finland is relatively sustainable with strict environmental regulations, low water stress, and low emissions. However, little protected land area and some pressure on fish stocks prevent the country from attaining an even better result. Norway has a high performance on low emissions and good land management. However, one area for improvement is Norway's depleting fish stock. Sweden attains a result similar to Finland, in terms of environmental sustainability, with generally responsible management of resources; limitations relate to the depleting fish stocks and very little protected land area (WEF, 2013:67).

The below-par performance of the U.S.A in terms of environmental sustainability is the consequence of several factors that include a lack of commitment to joining international treaties; a limited political will to firmly improve on critical environmental issues, the high pressure on the water resources for agriculture, relatively high CO_2 emissions and limited protected land area. The aforementioned concerns have been highlighted by the U.S.A Environmental Protection Agency (EPA), which also includes the need to protect habitats, especially on the coasts where urbanisation is moving faster.

Japan displays a mixed performance in terms of the 2012 environmental pillar, performing well in environmental policies (with high commitment to ensuring that regulations and standards are in place), however experiencing a high level of CO_2 emissions and pressure on water resources and on fish stocks (WEF, 2013:70). China continues to experience a major environmental challenge, such as high level of emissions and air and water pollution is worsening in several cities. The tangible deterioration of natural capital has induced the government to plan changes, such as increasing taxation and prices of coal and may introduce a tax on water use (WEF, 2013:70). Owing to low CO_2 emissions and good air quality, Brazil attains an above-average performance for environmental sustainability despite high level of deforestation (WEF, 2013:71).

India's environmental performance is characterised by a high level of pollution and few protected areas, depleting water tables, increasing population, infrastructure gaps, and water scarcity and contamination (Government of India, Ministry of Water Resources, 2010; WEF, 2013:71). The WEF, 2013:71 states that in India "68% of the land is prone to drought, …with 33% chronically drought prone….high incidence of fluoride, arsenic, iron & heavy metals has been found in isolated pockets in several of India's states".

In September 1987, the Montreal Protocol aimed to tackle the Ozone layer challenge (EC, 2009). In the absence of the Montreal Protocol, scientific modelling has projected a world in which nearly two-thirds of the earth's Ozone layer would be gone by 2065, with Ultra Violet radiation up by 650% and catastrophic consequences for life on Earth (Newman, 2009:2120). Instead, the hole in the Ozone layer appears to have stopped widening in recent decades (British Broadcasting Corporation (BBC), 2006).

Table 6.2.3-1 presents five selected high-profile international research efforts, namely: the Intergovernmental Panel on Climate Change (IPCC), the Consultative Group on International Agricultural Research (CGIAR), the Bill and Melinda Gates Foundation, the International Tokamak Experimental Reactor (ITER), and the global efforts to develop and deploy carbon capture and storage (CCS) technology.

In this context, internationally comparable indicators complement, rather than substitute, local indicators. According to the WEF (2013:65), high-quality data on the social and the environmental dimensions of sustainability are critical for international benchmarking, tracking progress, and analysing relationships among the different dimensions.

Archibugi and Coco (2005:181) state that "inter-country comparisons are meaningful, in spite of the social, cultural, and regional variety encountered in each of them". Archibugi and Coco (2005:179) nevertheless acknowledged the problem of lack of reliability of data in LDC, and therefore stated that "but the method applied for OECD countries cannot be used for LDC for the simple reason that relevant data are not available; rather, one can choose indicators that are available for more countries and be aware that the data are not as satisfactory and as accurate as they are for the OECD countries".

Critics of international indicator benchmarking such Lundvall et al. (2006), Srininvas and Sutz (2008) and Juma and Yee-Cheong (2005) argue that a global basis for measuring and assessing innovation strategies, incentives and regulations does not reflect the innovative activities taking place in developing regions. Aiginger, Okko andYlä-Anttila (2009:103-129) note that countries that show high level of innovativeness are those that are also most globalised. In this research context, success and performance of policies should be evaluated at the local level with policy experimentation in LDC.

Table 6.2.3-1: Five high-profile international research efforts

INITIATIVE	STRENGTHS	WEAKNESSES
IPCC Intergovernmental assessment The IPCC is the world's largest 'warning system': the Intergovernmental Panel on Climate for the assessment of climate change, established by the UNEP and the World Meteorological Organisation (WMO) to provide the world with a clear scientific view of the current state of knowledge in climate change IPCC has engaged over 3,000 scientists and cited over 40,000 peer-reviewed publications.	• Has yielded a landmark sequence of global assessments related to climate change • Comprehensive geographic representation and ownership • Engages governments and policymakers; clear policy • Extends knowledge on climate change; shaping research agenda and building research capacity • Synthesises and assesses a wide range of quality research around the world	• High-profile (if not critical) errors in some of its reports • Owned by all countries, but governed by none • Has moved from being an impartial scientific assessment body towards policy advocacy. • Perceived political bias • lack of transparency in many of the IPCC's processes and procedures [The 2010 IAC review of IPCC addresses some of weaknesses]
CGIAR Consortium CGIAR is a global partnership which aims to achieve sustainable food security and reduce poverty in LDC through scientific research and research -agriculture, forestry, fisheries, livestock, policy and the environment.	• Highly efficient investment, in food production • Without CGIAR: o World food production would be 4–5% lower; o World grain prices would be 18–21% higher; o Some 13–15 million children would be malnourished	• Currently undergoing radical reforms which are too early to assess—more centralised structures may result in better donor co-ordination and less duplication, but may adversely affect freedom of individual centres and exploratory research
BILL AND MELINDA GATES FOUNDATION Philanthropy-The Bill & Melinda Gates Foundation is the richest private foundation in the world, dedicated to bringing innovations in health, development, and learning to the global community.	• Supports innovative, risk-taking research, provides innovative incentives for the pharmaceutical industry to address tropical diseases • Sets an example to other wealthy philanthropists • Stimulates public–private partnerships and creativity • Agile due to freedom from limitations of government rigidity and policy	• Opaque governance largely driven by family interests. • Large investments create unintended consequences in LDC such as the concentration on 'high profile' diseases such as AIDS has created an internal 'brain drain' away from basic healthcare • Novel approach to grant making supports high risk.
ITER Large facilities/infrastructure ITER is an international project to design and build an experimental fusion reactor based on the 'tokamak' concept.	• Technical agreement was a catalyst for other agreements Project stimulated international cooperation—huge costs meant it would not have been possible without it.	• Time needed to build confidence between partners working in a new configuration • Difficulty of reconciling political and technical interests.
CARBON CAPTURE AND STORAGE (CCS) Government-Industry collaboration CCS is a range of technologies that have the potential to trap a significant proportion of CO_2 emissions from power stations.	• Brings the resources, expertise and research strengths of industry to address a major global challenge • CCS has catalysed intergovernmental co-operation at the highest level.	• Scale of the challenge and time required to solve it means further international agreements and funding are necessary • Resolution of a number of issues is needed relating to liability and regulation.

Source: The Royal Society (2011:78-100)

The five research initiatives presented in Table 6.2.3-1 reflect a balance of global challenges (climate change, food production, infectious disease, and environmentally responsible provision of energy). Within the five research initiatives, positive characteristics of overarching themes emerge. First, good governance, transparency and accountability are crucial to international collaborative frameworks. The ITER and IPCC have both faced governance issues (InterAcademy Council (IAC, 2010). The Gates Foundation's investments are largely driven by the interests of a single family and advisers, whom critics have argued are not sufficiently responsive to local needs. Second, multidisciplinarity, which refers to the interconnectedness of global research programmes, is essential. Multidisciplinarity can be attributed to the Montreal Protocol's and IPCC's success.

Third, funding and incentives are critical to addressing global challenges. Incentive structures play a vital role in supporting risk-taking research and encouraging behaviour change. For example, in reducing CO_2 emissions through carbon capture and storage (CCS) can be achieved through internationally agreed and effective carbon pricing framework. Fourth, involvement of industry in many global challenges is important. The CCS, for example, will require substantial investment from and the creation of an appropriate incentive structure by government and industry. The pharmaceutical industry has responded to the Gates Foundation's financial incentives to develop crucial drugs for saving lives in the developing world. Fifth, capacity building is vital that requires the use of local manifestations such as local indigenous knowledge or non-peer-reviewed research, such as the IPCC's use of 'grey literature', especially in the development of adaptation strategies which are cost effective, participatory and sustainable (Robinson & Herbert, 2001). Sixth, the use of global engagement, which requires availability of significant amounts of public funds, should be clearly communicated as the initiatives progress (Royal Society, 2011:100-101). To this end, the next section reviews the international context of innovation indicators.

6.3 INTERNATIONAL INNOVATION INDICATORS

Internationally comparable indicators include the European Knowledge Area (EKA), the EIS and OECD Manuals. Structural indicators of the European Knowledge Area (EKA) by the OECD (2007b:35) include government spending on human resources (on education), GERD by source of funds (private/public), level of Internet access per household/enterprises, S&T graduates: total/female/males, level of patent: European Patent, venture capital investments and ICT expenditure. According to OECD (2007c:35) the EIS contains indicators input indicators consists of S&E graduates, the population with tertiary education, broadband penetration rates, public and private R&D, innovation expenditures, ICT expenditures, early-stage venture and cooperating on innovation. Output indicators comprise high-technology employment, high-technology exports, sales shares of new-to-market/firm products and EPO/USPTO/Triadic (US, EU, and Japanese) patents, trademarks and designs. The next section reviews of trends in international NSI: main features and performance.

6.4 TRENDS IN INTERNATIONAL NATIONAL SYSTEM INNOVATION

Table 6.4-1 and Table 6.4-2 summarise STI performance for participating countries in a research by MONIT (monitoring and implementing national innovation policies) project.

Table 6.4-1: Summary: the result for participating countries in a research by MONIT project

GENERAL ASSESSMENT OF STI PERFORMANCE PROFILES	
Country	**Assessment**
Austria	*Strong*: Employment in medium/high technology manufacturing, innovative firms in manufacturing and services, value added in medium/high technology manufacturing. *Weak*: All others except business funding of R&D. *Profile*: Innovative industrial system.
Belgium	Strong: SME share in R&D, employment in medium/high technology manufacturing and high technology services, inward FDI, government funding of business R&D, business-funded R&D at institutions of higher education, tertiary education, venture capital. *Weak*: innovation expenditures, S&E graduates, PhDs, business funded R&D at government labs, participation in life-long learning, share of innovative firms in manufacturing and services, productivity, value added and high technology share. *Profile*: International and private funding systems, weak economic performance.
Greece	*Strong*: S&E graduates, high share of medium/high technology in GDP *Weak*: all others. *Profile*: Overall weak performance, strong in S&E graduates.
Finland	*Strong*: most indicators, except overall economic performance. *Weak*: inward FDI, share of innovative firms in manufacturing and services. *Profile*: Strong system with a paradox of less innovative system.
Ireland	*Strong*: employment in medium/high technology manufacturing and services, inward FDI, S&E graduates, innovative firms in manufacturing and services, labour productivity. *Weak*: Patents, business expenditure in R&D, government funding in R&D at labs and HEIs, tertiary education, life-long learning and knowledge investment. *Profile*: Strong company system, good overall performance, weak knowledge system.
Japan	*Strong*: patents, employment in medium/high technology manufacturing, business expenditure in R&D, share of R&D in overall budget, tertiary education, participating in life-long learning, knowledge investment, venture capital. *Weak*: SME share in R&D, employment in services, inward FDI and funding of R&D.

Source OECD (2005b:29)

The participating countries vary considerably, with significant differences in economic structure and policy priorities. The MONIT project identified the risk of fragmentation and lack of coherence (Arnold & Boekholt, 2002:16-18; OECD, 2005b:29). Norway has a relatively weak coordination and fragmented NSI, similar to that of South Africa, which has endured because of the culture of administrative fairness, statutory evaluation studies and institutionalised strategic intelligence (WEF, 2013:27). The relative lack of coordination in Norway is the result of "... the lack of a national arena for setting consensual priorities" (OECD, 2008:155). However, unlike the South African NSI, Norway is characterised by well-functioning and transparent public institutions and private institutions with strong performance in ethics and accountability. Markets in Norway are efficient, with labour and financial markets ranked 14th and 9th, respectively (WEF, 2013:27), which includes good capacities for strategic intelligence (OECD, 2007b:222).

Table 6.4-2: Result for participating countries in a research by MONIT project

COUNTRY	CONTEXT	GOVERNANCE
Canada	Canada is a branch-plant economy on the US periphery. Developing a stronger industrial base is a prerequisite for moving from resource- to industry-based development. It has managed to move its GERD/GDP ratio up since 1990, as well as the percentage of business R&D in some sectors, but industry's R&D efforts remain rather limited – especially given the amount of high-technology production in Canada. Canada has set itself a target of moving from the 15th to the 5th place in the world in terms of expenditure on R&D. Nevertheless, there seems to be no clear strategic response to the Canadian research and innovation policy community.	Canada is highly centralised with a wide network of federal government agencies and departments taking roles not only in steering research and innovation, but also in conducting a large amount of intramural governmental research. There have been rather frequent changes in governance and advisory structures, but the effects of the reforms appear to have been limited. Horizontal co-ordination has not been very effective. Existing advisory structures have little influence on government. Lack of continuity in government has undermined its role in developing effective governance. Effective advice essentially has a personal, not an institutional, character.
Denmark	The Danish economy is solidly SME-based, and Denmark has succeeded in creating a good level of welfare for its citizens, while making a modest overall investment in R&D. R&D is nonetheless a key element in government strategies and a doubling of R&D budgets has been announced. Basic research has especially high status and priority in Denmark – despite the industrial structure, which would normally tend to imply limited capacity in industry to absorb research.	Denmark is currently undergoing a radical reform in its entire governance system, with integration and coherence as central objectives. Denmark has a governance system where stakeholders in the research community have considerable influence on the direction of research through a mainly bottom-up process of allocating funding. The innovation part of the governance system is relatively small, in part because industry policy focuses on framework conditions rather than on public financial support.
Finland	Finland has been developing rapidly from a resource- to an IT-based economy, and has been making large investments in state R&D in order to support the associated growth in BERD. The strategy of massive	Finland has a quite lean and well-coordinated governance system, with a high level of commitment to research and innovation from the Cabinet. The Industry and Education ministries have separate research and

COUNTRY	CONTEXT	GOVERNANCE
	state investment in R&D during the 1990s is now being reviewed in a series of system evaluations.	innovation agencies, each with considerable autonomy. However, a high level of both formal and informal horizontal co-ordination.
Ireland	Ireland is widely regarded as the 'Celtic Tiger' and is in the process of catching up with the more R&D intensive countries in terms of GDP per head. It succeeded in increasing BERD/GDP rapidly during the early 1990s, but the growth has now tailed off. Most R&D is done by foreign multinationals, and while there are growing numbers of dynamic, Irish technology-based firms, the R&D-intensity of production overall has stagnated in the last few years. A massive investment in the state HEIs and research infrastructure, and in research on ICT and biotechnology, is being implemented.	Research and innovation have had low political priority in the past, with the main focus of development policy being on manufacturing production in high-technology industries. A comprehensive set of governance and co-ordination mechanisms was put in place in 1996, before the recent decision to increase research investment. In practice, the formal mechanisms have not been used during the period when the expansion was planned. During 2002, a government commission was appointed to analyse how to manage the overlaps and in transparencies that have apparently resulted.
Netherlands	The Netherlands' R&D-intensity tends to be little different from the OECD average, despite an industry structure that is comparatively technology intensive. GDP per head is typical of the cluster of North European countries. There are strong national traditions of consensus building and co-operation, which may play important roles in making a rather complex governance structure successful.	Governance in the Netherlands is strongly split between a decentralised style in research (the sphere of the education ministry) and a very hand on style by the ministry of industry. The research and innovation system has grown by accretion to become very complex, with large numbers of organisations involved, producing a risk of lock-in, which also means there is a good measure of de facto co-ordination. A new, high-level council (CWTI) has been created to prepare and co-ordinate policy decisions.
Norway	Norway is locked into largely low-R&D sectors, making it structurally difficult to use research as a motor for change. Raising the proportion of GDP to be spent on R&D to 3% is nonetheless a long-standing national goal. Sustaining present high, oil-supported levels of welfare in the future will not be possible without generating major new industry. There has been some recent success in setting national research priorities likely to address the issues, though reforms are likely be needed in parts of the innovation infrastructure	Norway has a relatively centralised research and innovation funding system with one powerful agency dealing with research and innovation. At the same time it has, for its population size, quite an extensive network of research institutes. It has enthusiastically embraced many ideas of the New Public Management (NPM), including the principle of management by objectives. Ministries' interests in research are strongly sectored, and there is a tendency in some ministries towards very detailed management of the research expenditures on the single national research council.
Sweden	Sweden has moved quickly to become the world's most R&D-intensive economy, but has been losing relative position in	Sweden's governance system is well geared to a high level of commitment to science and

COUNTRY	CONTEXT	GOVERNANCE
	terms of GDP per person for a long time now. The implication is that there is something fundamentally wrong with Swedish assumptions about how the research and innovation system works.	research. Horizontal co-ordination is achieved partly by the education minister assuming responsibility for research in the government. However, the weakness in the research system is its poor links with innovation, which appears to be partly due to its governance model.
UK	The UK is said to be suffering from similar innovation paradoxes to Sweden. Despite its strong position in the world in terms of academic science, the share of its business R&D is decreasing. Changes in the governance structure are geared to maintaining scientific excellence while improving links with industry. A declining manufacturing base might be compensated in a growth in business areas such as biotechnology and pharmaceuticals.	The UK has a strong central function for science and research with its Office of S&T. Innovation governance has been more haphazard with little involvement of stakeholders. Indeed, the UK lacks the strong industry-oriented R&D policy measures found in many other North European countries. However, the role focuses more on science-related policy issues (such as BSE) than on horizontal research and innovation policy coordination.

Source: Adapted from Arnold & Boekholt (2002:16-18)

Figure 6.4-1 by the Nordic-style the Finland, Norway and Sweden innovation agency, the Valtion Teknillinen Tutkimuskeskus (VTT) (State Technical Research Centre) indicates the effort to split roughly the innovation process among three stages, namely 30/40/30.

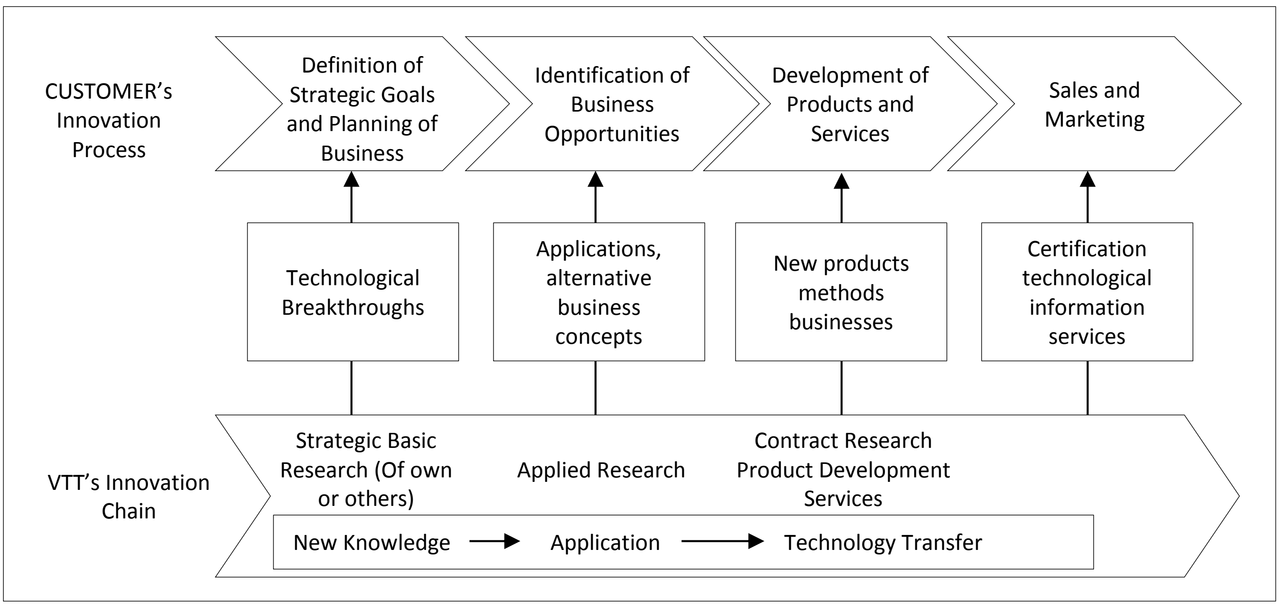


Figure 6.4-1: VTTS of Sweden innovation process
Source: OECD (2007b:197)

The VTT framework, Figure 6.4-1, distinguishes four broad government policy strata and organisational development and diversity organisations undertaking. The first is the strategic research for generating new knowledge required for industrial STI system. The second is the directed research technological development, which can be adopted in South Africa. The third and the fourth are applied research and technological development, respectively, both of which can be associated with the fine-tuning or upgrading of established technologies. The third and the fourth strata have already been in use in South Africa in the provision of services to assist enterprises in exploiting existing know-how from various sources. No single individual institution fits neatly within the four strata are vertically integrated within different institutions. In South Africa, the CSIR is active on all four levels.

It may be argued that South Africa should therefore adopt Figure 6.4-1, the Nordic-style innovation agency, either within the NRF or as a separate body. These international innovation supporting agencies include the VTT in Finland, the Canadian International Development Agency, CIDAUT in Spain, the SP Technical Research Institute of Sweden, SINTEF in Norway, Fraunhofer in Germany and IMEC in Belgium, provide considerable examples of variation of proactive management of research and innovation for South Africa. The variations include the use of core funding to develop capabilities (knowledge, technology platforms, specialised test and certification equipment, and approvals) and the use of those capabilities to reduce innovation risks for commercialising companies. The CIDAUT, Spain's R&D Centre in Transport and Energy, for example, actively leads SMEs in the Spanish automotive components sector into new technologies and helps them design new products. In Italy, the branch-focused institutes of Emilio Romagna play a similarly proactive role (Rush, Hobday, Bessant & Arnold, 1996). In South Africa the CSIR is a long-term trend away towards the VTT model. It operates a model that is slightly more oriented towards engineering and design than that of most northern European industrial research institutes, but one that appears to be relevant in South Africa that complements the role of HEIs research. Another important lesson for South Africa is that the Nordic countries have a dual tax system in which corporate taxes are kept low to help firms stay internationally competitive despite the high overall tax level. On the negative, the Nordic countries are characterised by high CO_2 emissions and energy consumption per capita, and low environmental taxes.

By virtue of size, Brazil is an example of a federal system of innovation, which has functioned in practice alongside a strong commitment to building state-level regional NSIs. The positive performance of the Brazilian states is as a result of being empowered to raise taxes that are deployed towards innovation support through state-level innovation funds such as the Foundation for Research Support of the State of Sao Paulo (FAPESP). The Brazilian arms-length Centre for Strategic Studies and Management Science, Technology and Innovation (CGEE) play an important role in supporting policy learning. Some of the essential NSI practices and instruments that the South African NSI can adopt from Brazil include administrative transparency, the databases of Plataforma lattes, the Innovation Fund (FINEP), the resource levy-supported sectoral funds and the incubator movement. However, a remarkable characteristic of inequality in Brazil is the persistence of unequal income and wealth concentration throughout the various political periods and regimes (Soares & Podcameni, 2014:21-43). The NSI in Brazil is permeated by structural characteristics of a highly unequal and heterogeneous country (Soares & Podcameni, 2014). Brazil's NSI success and experience in attracting foreign-funded R&D centres is a confirmation of the importance of South Africa to develop a critical mass of engineers and researchers.

Export-led economies include Finland, Korea, Austria, Sweden and Belgium. Finland has a high-level stakeholder-based steering committee, the Research and Innovation Council. Like Brazil and South Africa, Finland, exhibits wide NSI regional disparities. Finland is a country with a large public sector and a relatively large number of state-controlled firms. It is a country that, by any of a number of measures, has seen significant increases in innovative inputs such as R&D spending, human resources for S&T in the past 10 years and made improvements in economic performance. Finland's success can be attributed to the adoption of a long-term perspective and systematic approach to policy making, since the early 1980s in order to avoid resistance and produce national consensus (OECD, 2005b:13). In the global economy, Finland is strongly specialised in two industrial sectors: ICT and forest, both of which have played an important role in the country's NSI. There are, however, a number of signals of need for change, especially to higher education and research (Aiginger et al., 2009:103-129). University reform, together with recently implemented University Inventions Act, is likely to improve innovation management and inventions commercialisation in Finnish universities. Policy discussions have paid attention to the low level of 'internationalisation' of the Finnish research and university system. According to the Finland University Act (1997), universities have four main tasks: promote free research, to promote scientific and artistic education, provide higher education based on research and educate students for development. The Act gives Finland HEIs more freedom to undertake activities including, research which supports the need of business, and to access external funding. In allocating research funding, the National Technology Agency- TEKES fosters HEIs-business networking. TEKES has had positive effects of increased enterprises commitment to R&D, strengthened HEIs-industry links and international collaboration. Major successes associated with TEKES include Nokia, dairy processor Valio, with its low-lactose products, and software enterprise Rovio (OECD, 2005c:114-115). However, the “new paradigm globalisation” competition from organised units such as the BRICs, namely: Brazil, Russia, India, China and South Africa presents Finland with global economy challenges (Aiginger et al., 2009:103-129).

In comparing Brazil, Mexico, India and South Africa, Albuquerque (2003) coined the term ‘immature systems of innovation’ to describe these countries NSIs. The term is rather punitive, as each of these countries demonstrates both strength and weakness in certain scientific fields as well as produces some world-class innovations. South Korea’s predicted real GDP growth rate of 4.3% per year is expected to exceed that of Japan in the near future and to be the highest among the OECD countries. The country’s rapid economic growth and industrial development is attributable to the highly educated and skilled work force as well as to the dynamic market and active R&D investments by both the government and the private sector (Royal Society, 2011:18).

Despite the authoritarian nature of South Korea, the high accord and expectation given to education and educators is an essential ingredient of the country’s success. Korea functions with a high-level innovation council and makes extensive use of foresight. The particular style of governance is uniquely Korean, reflecting the country's deep culture as well as the power of the family-owned chaebol conglomerates, which are close to the government. In the early years of Korean industrialisation, R&D was state-driven. Perhaps the most important learning experience for South Africa from Korea and Finland is that education matters, and skilful location of universities, based on government-industry-community participation can catalyse regional and industrial development.

Belgium and Austria are both small open economies, which exhibit a diversity form of governance with strong regional dimensions. Both countries have evaluation mechanisms in place, but show limited efficacy. A positive lesson for South Africa is Belgium's Curriculum Vitae database, which provides a fluid employment regime. Austria leads the way in extending state incentives to start-ups during the ‘before profit’ phase, a direct subsidy for R&D, another positive lesson for South Africa from this research perspective.

Austria’s economic development has been highly successful, starting from an unfavourable position after World War II to occupying 9th position among 30 OECD countries in terms of GDP per capita during 2012/2013 (OECD, 2005b:68). However, Austria has been lagging behind in terms of total R&D investment as a share of GDP, largely due to low levels of industry-financed R&D. Conversely, there is a growing awareness in Austria that a transition to a more knowledge-driven growth path, a “need of a new growth paradigm” is required which is being implemented (OECD, 2005b:69). Similar to South African NSI, Austria’s innovation policy needs to be much more “centre stage” within overall economic policy. Interactions between HEIs and the Public Sector Research Establishments (PSREs) and business need to be enhanced and R&D expenditure as well as other investment in knowledge further increased. The Netherlands and the UK are examples of countries with good economic and innovative performance but with growing concerns about future innovative and economic performance (OECD, 2005d:11). Having achieved high levels of GDP per capita yet, taking into account the specific conditions, both countries remain concerned about better harnessing the capabilities of strong science systems to fuel future economic growth and improving the innovation capabilities of firms (OECD, 2005d:12).

The Netherlands is one of the most affluent countries within the OECD, with a high level of income and wealth based on a highly open economy. A lesson for South Africa is the growth of employment facilitated by the “Dutch Model”, characterised by low costs and wage restraint. Another positive aspect is that Netherlands has a transformed “committee corporatism”, which improves coordination and coherence (OECD, 2005b:48). However, the 2009 global recession exposed some weaknesses in Dutch economic performance, in particular a weak productivity growth (OECD, 2005b:147). The Netherland’s Innovation Platform has seen similar developments to Austria of stakeholders’ integration in an otherwise fragmented system (OECD, 2005d:47). Table 6.4-3 summarises the positive and negative aspects of stakeholder involvement in the Netherlands. Stimulating the creation and growth of high-technology firms and improving links between the Netherlands HEIs and PSREs and the private sector through improving the institutional framework for cooperation will be critical for the efficient future NSI functioning (OECD, 2005d:50). Moreover, the Netherlands is facing the threat of a shortage of human resources for S&T unless appropriate measures are taken (OECD, 2005b:15).

Table 6.4-3: Positive and negative aspects of stakeholder involvement in the Netherlands

POSITIVE AND NEGATIVE ASPECTS OF STAKEHOLDER INVOLVEMENT IN THE NETHERLANDS	
Positive aspects	Negative aspects
• Increases the user orientation of policies and consequently effectiveness. • Invites more transparency on the rules of the game. • De-politicises some contested decisions. • Circumvents departmental turfs fights. • Facilitates networking between different stakeholder groups.	• Lengthens the decision-making process. • Increases the transaction costs of policy making. • Composition of stakeholder groups can be skewed in favour of certain interest groups or positions.

Source: OECD (2005b:50)

Table 6.4-3 provides lessons to South Africa on the positive and negative aspects of stakeholder involvement. Historically, the UK has performed poorly in terms of macro-economic stability compared to other G7 countries. Volatility of economic growth, inflation, employment and interest rates, partly reflecting policy shifts has hindered the long-term health of the economy (OECD, 2005b:15). The UK is successful in a number of science-based sectors, particularly those based on life sciences and chemistry, but much less so in sectors based on physics, apart from a few notable exceptions such as Aerospace. A key reason for this is a long-term deficiency in the training of craftsmen and technicians, including macro-economic instability, trade union militancy, poor management and a failure to focus on fast-growing European markets in the 1950s and 1960s. Similar to the South African context, improvements in education and training are one part of realising the UK innovation a strategy (OECD, 2005b:15). The UK has introduced a number of schemes designed to make the HEIs more "user friendly" towards industry. Higher Education Innovation Fund (HEIF) funds industrial liaison offices, expertise in IPR, provision of business advice, funds identification and commercialisation of research and mentoring and enhanced dialogue with business and business support organisations. Knowledge Transfer Partnerships supports the appointment of graduates to industries in order to undertake HEIs driven innovation projects. The Faraday Institutes are public/private partnerships that translate the HEIs research into industrial technology. The LINK scheme funds long-term collaborative research carried out jointly by HEIs and the productive sector (OECD, 2005b:20).

Sweden's performance in S&T is high by most OECD standard indicators. However, its position as a leading high-income country in Europe has gradually eroded. In the early 1990s, Sweden went through a deep recession and currently faces a challenging task of sustaining high growth, while maintaining a high welfare state (OECD, 2005b:181). Similar to Norway, Sweden offers the paradox of high R&D expenditure with lower than expected outcomes (Edquist, 2010:9). The Swedish "paradox" (high investments in R&D) do not result in greater economic growth and innovation) presents a major challenge (Edquist, 2010:9-10). Swedish companies appear to prosper more internationally than locally. The implication is that Swedish companies are located less at home and more abroad (Edquist, 2010:9-14), which require a new 'suste', to increase and sustain technological and economic competitiveness (OECD, 2005b:14). Sweden scores highly on a number of key innovation indicators such as overall R&D expenditure, scientific publications and patenting in the U.S.A, but international ranking of GDP per capital has slipped due to periods of negative growth.

In Sweden, links between industry-science relations (ISR) tend to be dominated by relations between a small number of MNEs and the seven oldest and largest HEIs (OECD, 2005b:19). Figure 6.4-2 provides a lesson for the South African context by the Swedish National Board for Technological Development (STU). The model illustrates how R&D activities can be integrated for a mature innovation system. In Swedish the research areas in Figure 6.4-2 are funded specifically in order to provide human and knowledge resources to industry, through the use of strategic and applied research needs, which are updated regularly in partnership with industry. In South Africa, some of the instruments with a similar function to the STU programme include the IF, the Centres of Excellence and Equipment Programme, the National Biotechnology Strategy, the AMTS and the THRIP. The THRIP programme appears to have played the major role as a focusing device for Higher Education Expenditure on Research and Development (HERD). However, the instruments and mechanisms for HERD have probably been inadequate, with resources consequently spread thin over too many areas and activities.

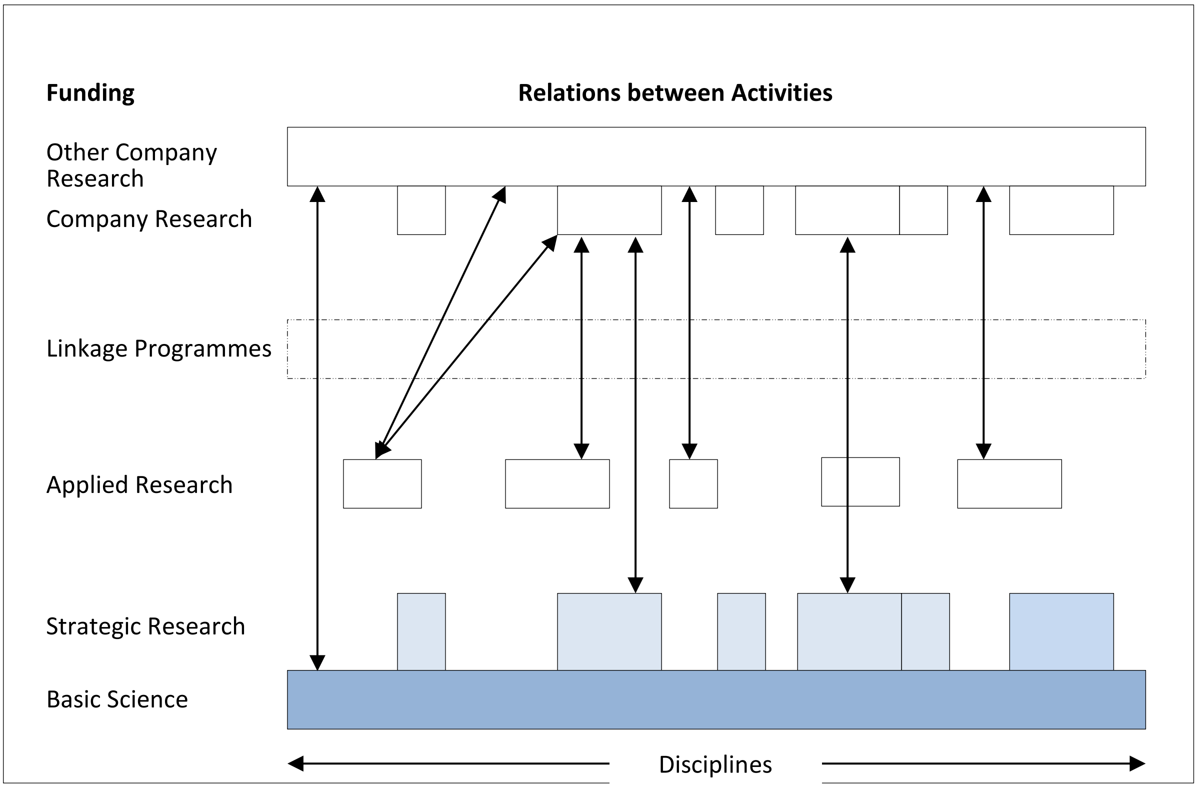


Figure 6.4-2: R&D activities in a mature innovation system
Source: OECD (2007b:190)

Japan is categorised among those "countries where trend growth declined or stagnated", and the decrease in the GDP per capita growth rate stands out from other countries that experienced decline or stagnation during the two decades (OECD, 2005b:117). The OECD Growth Project indicates that Japan's economic performance sharply declined from the 1980s to the 1990s

(OECD, 2005b:10). Japan also faces the research paradox with strong innovative input and weak innovative economic performance. Much greater competition from other East Asian countries creates an additional challenge (OECD, 2005b:13). Addressing the challenges will require a radical change in Japan institutions and their interaction with the environment.

In Japan, the total regular Fiscal Year 2009 government budget for S&T was JPY 3,555 billion. The five-year Japan S&T Basic Plans prescribed by the S&T Basic Law have been the most important instrument for developing an integrated policy, which states that "basic research consists of two types: Type-1 basic research that is conducted based on the free ideas of researchers in S&T, including human and social sciences; and Type-2 basic research that aims at future applications based on policies" (Government of Japan, 2006:2).

Around 83 per cent of Japan's "Type-1 basic research concerns basic university funding, mainly national universities, whilst another 13 per cent relates to so-called Grants-in-Aid (*kakenhi*). Altogether, the category of basic research makes up 41.5 per cent of the total government S&T budget. Thus, the real target of the overall government prioritisation process is the remaining 58.5 per cent of government S&T expenditure. Some 47.5 per cent of total government S&T expenditure, falls under the category of "policy mission oriented research", while the final 11 per cent is referred to as "system reform & others" (Stenberg & Nagano, 2009). In Japan, there is a strong tendency for each ministry to build up its own research system centred on its own research institutes. Prior to 1995, virtually all the government funding of Japan's national universities came from the Ministry of Education, but since then other ministries have gradually increased funding of national HEIs (Stenberg & Nagano, 2009). In Japan, the government has removed restrictions impeding PRI and national HEIs (as well as individual researchers) to engage in commercial activities and collaborative partnerships with the productive sector. National research institutes will no longer suffer offsetting cuts in government funding when they accept funds from industry (OECD, 2005b:19). The next section undertakes a review of public administration and public policy from an international perspective.

6.5 INTERNATIONAL PUBLIC ADMINISTRATION AND PUBLIC POLICY

Much of the literature that relates to international public administration and public policy has been covered in earlier chapters. From an international context, the public sector innovation-growing social needs, together with budgetary constraints, require radically new and innovative public service models. The global weak economic recovery and is plagued by faulty macroeconomic policies and other problems, which have spilled over to the developing world, as in the case of the

2009 world recession (Weisbrot & Ray, 2011:31). Governance, as a form of public administration, is increasingly appearing in policy debates across Europe. According to the CEC (2001), governance means rules, processes and behaviour that affect the way in which powers are exercised at European level, particularly as regarding openness, participation, accountability, effectiveness and coherence.

Arnold and Boekholt (2002:6) identify three layers of governance structures from an international context. The first and most important layer for policy design and overall strategy formulation for STI lies at the level of governments, departments and, to varying degrees, advisory bodies. The 'middle level' consists of research funders (typically research councils, funding institutes and dedicated agencies), which have the responsibility for allocating funding to the research performers (universities, research organisations and laboratories, firms). The third level in the governance system consists of those actors that perform research and innovation and are the direct beneficiaries of public funding for R&D.

The economic structure in each of country determines the main R&D performers of each of country of the private sector. In the last decade, there has been increasing demand for good governance and, particularly, the need for a more coherent systemic approach in research and innovation in the areas of (i) the modes of knowledge production; (ii) the nature of (hard and soft) technologies; (iii) the way industry organises both knowledge acquisition and physical production; and (iv) the priorities of those who pay for knowledge production – sometimes discussed in terms of establishing a new social contract between science and society (Arnold & Boekholt, 2002:6-7).

Internationally, public administration remains weak largely owing to a shortage of human resources and deficiencies in staff training and motivation (United Nations, 2005:13). Table 6.5-1 presents some reasons for embarking on revitalisation efforts in the area of international public administration.

Table 6.5-1: Frequently cited reasons for embarking on public administration revitalisation

FREQUENTLY CITED REASONS FOR EMBARKING ON PUBLIC ADMINISTRATION REVITALISATION
Notwithstanding differences within and across regions, the rationale frequently cited for embarking on revitalization efforts includes the following: a) Promoting ethics, transparency and accountability. b) Enhancing public service efficiency and effectiveness, especially in the delivery of public services (however, interest in performance and productivity management and in value-for-money auditing has been particularly observed in developed economies, emerging markets and economies in transition. c) Ensuring the responsiveness of public administration to citizen needs and legitimate demands (through the adoption of citizen charters, dissemination of service pledges, and implementation of quality service initiatives). d) Promoting human development (and achieving the MDGs). e) Promoting economic growth and macroeconomic stability (by acquiring and applying the capacity to implement programmes geared towards promoting investor confidence and creating an environment conducive to private sector participation in development). Other reasons cited for revitalising administrative systems, though less frequently than the preceding ones, are as follows: f) Preventing and resolving conflict, and development of emergency preparedness and community policing (for countries faced with threats to security or emerging from conflict). g) Applying information and communication technologies to improve internal management processes and external service delivery systems, and promoting civil service automation (especially the case in well-established and rapidly changing administrative systems). h) Repositioning the public service for the challenges of democratisation and economic liberalisation (Africa, Central, Eastern and South Eastern Europe and the Commonwealth of Independent States). i) Promoting popular participation in local governance and implementing decentralisation programmes (an aspect of democratic reform). j) Preparing national economies for integration into larger entities (for countries seeking admission into the European Union, accession to the '*acquis communautaire'* is a prerequisite, which entails subscribing to certain basic governance and public service values). k) Creating an environment conducive to private sector growth and development. l) Coupling pay and employment reforms with the reassignment of posts and miscellaneous redundancy management programmes.

Source: United Nations (2005:8-9)

Table 6.5-1 indicates that convergence of views relate to integrity, efficiency, effectiveness and responsiveness of public institutions for economic growth, macroeconomic stability and human development. The next section discusses trends in international NSI research and knowledge.

6.6 INTERNATIONAL RESEARCH AND KNOWLEDGE SYSTEMS

Improving the ability of business to exploit the outputs from the HEIs and public research institutions (PRI) is at or near the top of the innovation policy maker's agenda in most OECD countries (OECD, 2005b:16). Three main factors govern the effectiveness of (international science and research (ISR): (i) the orientation of HEIs and PRIs to the needs of the productive sector; (ii) the links between HEIs/PRIs and the productive sector; and (iii) the need of business firms for the outputs of the research base and their ability to absorb and exploit them (OECD, 2005b:17). However, opponents of ISR argue that most HEIs spin-outs are of little economic significance with too narrow and too far-fetched technology base for commercialisation (OECD, 2005b:20). This research shares similar views with Britez and Peters (2010) that internationalisation of higher education is a way to open discussion about the construction of an alternative cosmo-political vision of the university and is necessary if the university is to fulfil any historic tasks concerning the creation of globally aware citizens (Britez & Peters, 2010). The DHET strategic plan of 2009 indicates that South Africa should become a preferred destination for international students and staff, particularly those wishing to pursue postgraduate studies and research. According to the International Education Association of South Africa (IESA, 2005), South Africa should commit itself to a dual process with regard to internationalisation. Internationalisation can be facilitated through, inter alia; the integration of international and intercultural elements into higher education's core business in a manner that addresses national needs and strengthens institutional curricular and outreach programmes (IESA, 2005).

From an international perspective, there are three types of research institute archetypes. First are the research association institutes, which tackle common problems within one or more branches of industry and then became institutionalised in the form of institutes. Second is the technology-push institutes set up in order to promote industrial development. SINTEF in Norway, Fraunhofer in Germany and IMEC in Belgium fall under this category. Third are the service-based institutes, such as the SP Technical Research Institute of Sweden, which generally focus as on early years on measurement, testing and certification. VTT in Finland is a mixed case, as a policy decision transformed a services-focused institute into a technology-push institute (Arnold, Brown, Eriksson, Jansson & Muscio, 2007:45-47). HEIs are central players in the European NSI. However, European HEIs are hampered by a combination of excessive public control, and bad governance coupled with insufficient funding opportunities (Veugelers et al., 2009:240-241).

Since 1984, EUFP has been the main tool through which Europe collectively delivers investment for Research, Innovation and Science (European Commission, 2010). Promoting global collaboration will enable South Africa to be one of the principal beneficiaries of, for example, the European Union Framework Programme (EUFP) and the International Council for Science (ICSU). This research is of the view that the South African NSI will require, through deliberate active measures, to promote international collaboration and linkages across boundaries, which are essential components of knowledge transfer and exchange. International collaboration is required, for example, for technological learning and adaptation in the South African aerospace industry.

Approximately 50% of patents now registered in the U.S.A Patent and Trademark Office are from outside the U.S.A—a figure that has remained largely constant since 1989 (U.S.A Patent and Trademark Office, 2010). Universities play a key role in the U.S.A innovation system and are more often engaged in research at the scientific and technological frontier. Through industry-HEIs research collaborations the HEIs direct research toward solving industry problems or gaining access to additional research funds (Chavula & Konde, 2011:4). The industry supported R&D expenditure in U.S.A universities stood at $2.4 billion during 2006 (Chavula & Konde, 2011:5). In the U.S.A, the number of patent applications filed by reporting universities and colleges increased from about 7,200 to 11,000 between 2003 and 2007 (United States National Science Board, 2010). According to the U.S.A Patent and Trademark Office (2010), most of the patents granted to universities are in the fields of chemistry, biotechnology and pharmaceuticals. Table 6.6-1 presents a summary of other benefits of collaborations of industry-HEIs.

Table 6.6-1: Benefits of collaborations of industry-HEIS

BENEFITS OF COLLABORATIONS OF INDUSTRY-HEIS
• Success in creating and nurturing an R&D culture in public HEIs that takes account of business priorities and the potential for both business partnerships and follow-on applications research including contributions to curriculum development. • The reduction in research duplication and progress towards commercialisation by developing research management centres, monitoring units and even companies which oversee the entire. • Providing additional stimulus and support for research in HEIs, including sometimes substantial investments in world-class facilities and joint research units. • Success (due to various mixtures of exhortations, funding initiatives and self-interest) in developing a more entrepreneurial spirit at the HEIs. • Extra income for HEIs through the sale of patents, licences, royalties and from consultancy and teaching work. In Hungary some 30 per cent of HEI income comes from non-government sources. • Involvement in some form of local regeneration activity. • Recognition of the HEIs contributions to society at local, regional, national and international levels. • For the productive sector, addressing of operational and management problems and acquisition of HEIs expertise, technology, personnel training, efficiency, competitiveness and profitability. • Development of graduates with appropriate employability skills to add value to productive sector.

Source: Collated from Brown et al. (2003:141-142)

Similar to the U.S.A, Finland, Canada, and Korean governments have elected to forego ownership of IP, which came as a result of publicly funded R&D (Wolson, 2003:122-123). The HEIs in the U.S.A have the most advanced IP management operations, attributed mainly to a key statute enacted in 1980, the Bayh-Dole Act and 1984 amendments, and related regulations. Bayh-Dole permits a university, small business, or non-profit institution to pursue ownership of an invention in preference to the government. Universities may not assign their ownership of inventions to third parties, except to patent management organisations. Universities must share with the inventor(s) a portion of any revenue received from licensing the invention. Any remaining revenue, after expenses, must be used to support scientific research or education (Wolson, 2003:122-123). The experience in the U.S.A from the period the Bayh-Dole Act has resulted in enterprises often shying away from working with universities out of concern that the resulting IP would be jeopardised. Applying Bayh-Dole in the South African context could be overly prescriptive and may push South African enterprises to outsource R&D to other private providers rather than to universities. In South Africa, it may be more prudent to continue with a policy vacuum than to implement policy which restricts the research funding environment by alienating funders. A middle-ground option might involve a formula for benefit-sharing between government and the institutions which generate the proceeds (Wolson, 2003:124-126).

In Japan, in order to facilitate an efficient process of IP, the 1998 Law Promoting Technology Transfer from Universities was enacted in response to a perception that the HEIs were not effectively exploiting IP. Procedures were put in place to grant legal personality to national universities. The Law provided for the establishment of technology licensing offices (TLOs) by offering financial support and loan guarantees from the government.

This research shares a similar view with Ocampo (2011:14) who states that "a delicate balance must be struck between the advantages and costs IPR have for technologically dependent countries". Supportive reforms should include a broader room for compulsory licensing on Trade-Related Aspects of IP Rights and on public health of the WTO, the strengthening patenting standards and the limiting the length of patent protection (UNCTAD, 2012:88-92). Brazil in the early 2000 enacted legislation to stimulate HEIs technology transfer which, by accepting research funding, obliged HEIs to comply with conditions such as clarifying ownership of inventions and ensuring that inventors share proceeds generated by exploitation of a HEI's invention. However, owing to lack of capacity, information and funds, institutions have been slow to implement the relevant policies. Nonetheless, technology transfer offices have been established in almost half of the main Brazilian universities.

As shown in Figure 6.6-1a and Figure 6.6-1b, the G20 countries have been increasing research productivity and most have scaled up the proportion of GDP spent on R&D. The U.S.A produces 20% of the world's authorship of research papers with 10 dominating world university league tables (Academic Ranking of World Universities (ARWU, 2010). The U.S.A also invests nearly US$400 billion per year in public and private R&D (U.S.A National Science Board, 2010). The UK, Japan, Germany and France each also commands strong positions in the global league tables of about 59% of all spending on science, globally. However, these countries do not completely dominate global science (Royal Society, 2010). China is also the third largest R&D spender globally, and has increased research publications, moving to the second highest producer of research output in the world (Royal Society, 2011:17: Aiginger et al., 2009:129). Between 2004-2008 period, China accounted for approximately 8.5% of the world's papers published in journals indexed by Thomson Reuters (Adams, King & Ma, 2009:6). India has replaced the Russian Federation in the top ten, climbing from 13th in 1996 to 10th between 2004 and 2008, India, Brazil, South Korea, Turkey, South East Asian nations such as Thailand, Singapore and Malaysia, and European nations such as Portugal, Greece and Austria have all improved research standings in the global scientific league tables. India produces roughly 2.5 million sciences and engineering graduates' each year.

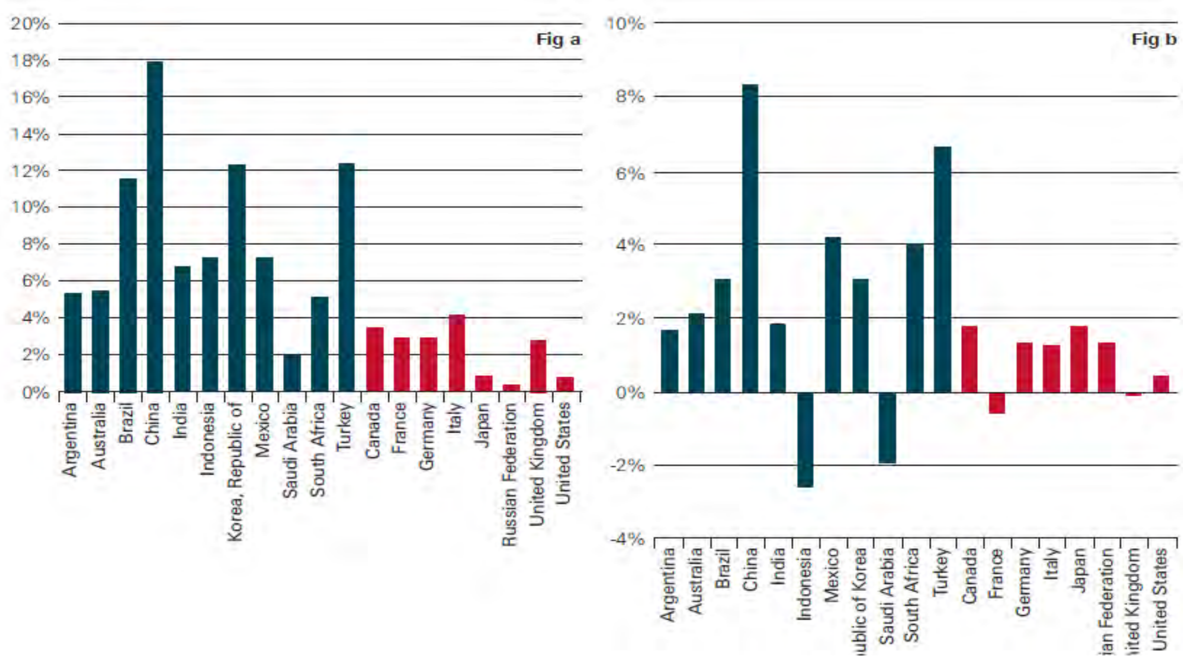


Figure 6.6-1a: Science in the G20 and G8 labelled in red, annual growth in publications 1996-2008

Figure 6.6-1b annual growths in GDP spending on R&D 1996-2007

Source: The Royal Society (2011:20)

The growth of commitment to science in a number of the non-G8 nations has taken place in tandem. For example, Turkey has improved its scientific performance at a rate almost rivalling that of China. Having declared research a public priority in the 1990s, the Turkish government increased spending on R&D nearly six-fold between 1995 and 2007. The proportion of Turkey's GDP spent on R&D rose from 0.28% to 0.72% and the number of researchers increased by 43% (OECD, 2010a). Turkey produced four times as many papers were published in 2008, as in 1996 (OECD, 2010a) and now spends more annually in cash terms than Denmark, Finland or Norway (Royal Society, 2011:17-20). The aforementioned commitments are critical lessons that should be emulated by the South African government.

The number of publications from Iran has grown from just 736 in 1996 to 13,238 in 2008—making Iran the fastest-growing country in terms of numbers of scientific publications in the world (Science-Metrix, 2010). In August 2009, Iran announced a 'comprehensive plan for science' focused on higher education and stronger links between industry and academia (Sawahel, 2009), which has resulted in the establishment of a US$2.5 million centre for nanotechnology is one of the plan's by products (Royal Society, 2011:17-20). In 1996, Singapore invested 1.37% of GDP in R&D and reached 2.61% of GDP in 2007. The number of scientific publications has grown from 2,620 in 1996 to 8,506 in 2008, almost half of which were co-authored internationally. The Agency for Science, Technology and Research (A*STAR) is central to the Singapore government's commitment to investment in world class research and infrastructure. A*STAR oversees Singapore's 14 research institutes and associated centres within flagship developments such as Biopolis and Fusionopolis (Royal Society, 2011:21).

In the aftermath of the global economic crisis in 2008, the private sector has struggled to maintain the levels of investment in R&D. After four years of 5% growth in R&D investment year-on-year, in 2009 R&D spending by the world's leading 1,400 business R&D investors fell by 1.9% in 2008 (EC, 2010). Microsoft is an example of a private company, which has set up a number of laboratories and businesses in fields such as healthcare, energy, environment and robotics. Many companies have followed similar models such as Sanofi-Aventis, which have R&D operations in China, Japan, South Korea, India, the USA, France, UK and Denmark and Shell, which has technical centres in the USA, the Netherlands, UK, Canada, France, Germany, India, Norway, Oman, Qatar and Singapore (Royal Society, 2011:32).

Increased policy attention by the international community is needed in the areas that relate to the financing of SST, for example, increasing foreign share of aid to the energy sector in sub-Saharan

Africa should be a priority. The overseas development assistance (ODA) disbursements to the sub-Saharan Africa energy sector in 2010 were only $806 million compared to the World Bank estimates of investment required of $41 billion per year. Among the 27 countries of the EU, collaboration grew from 32% of total publication output in 1996 to 46% in 2008. In the five years to 2000, France and Germany co-authored 12,516 articles, which increased to 23,291 in the five years to 2008 nearly 100%. An increase in funding from the Commission's programmes has contributed to the level of growth (EUROPA, 2010; EC, 2010). Having explored the international NSI trends, the next section is the Chapter summary.

6.7 SUMMARY

This chapter has undertaken a literature review on the construct of sustainable development through research in the NSI from an international perspective by drawing out both context-specific and generic transferable country experiences in South Africa. The chapter has explored various NSI related models and research institute archetypes that provide important lessons for South African NSI, such as the VTT in the Nordic countries. From an international perspective, growth of commitment to research and science has taken place in tandem, which provides a critical lesson that should be emulated by the South African government. Internationally, the research has identified that public administration remains weak largely owing to a shortage of human resources and deficiencies in staff training and motivation. The next chapter presents the research design for examining the construct of sustainable development in South Africa, which has been a consequence of research commercialisation in the NSI.

CHAPTER SEVEN

RESEARCH DESIGN AND METHODOLOGY

7. RESEARCH DESIGN

Chapter Six consisted of the literature review on the construct of SD through research in the NSI from an international perspective that drew both context-specific and generic transferable country experiences for policy developments in South Africa. This chapter presents the research design used to examine the NSI landscape, specifically with respect to HEIs.

7.1 INTRODUCTION

The rest of the NSI actors' landscape has been reviewed using literature and secondary data. This chapter is structured as follows: section 7.2 considers the research design and methodology, while section 7.3 presents the research participants. Sections 7.4 and 7.5 discuss the quantitative and qualitative data research instruments respectively. Section 7.6 explains the use of secondary data for this whilst Section 7.7 and 7.8 presents quantitative and qualitative data collection methods respectively. Section 7.9 and 7.10 presents the data analysis procedure and data triangulation. Section 7.11 is the research cognitive mapping, while section 7.12 deals with the ethical issue consideration. Section 7.13 deals with validity and reliability issues and section 7.14 summarises and concludes the chapter.

A research design is a plan or proposal to conduct research, involving the intersection of philosophy, strategies of inquiry and specific methods (Creswell, 2009:3). In this research context, the research design describes the procedures for conducting the research, including when, from whom, under what conditions the data will be obtained (McMillan & Schumacher, 2011:110). According to Kane and O'Reilly-de Brun (2001), a problem or an issue that a researcher is probing determines the research design as well as the research methods and techniques to be used. The ontological position has been adopted which is contained within enquiry of social phenomena of sustainable development in South Africa through research and the continual process of the NSI actors to drive innovation. Ontology in this research context has been used to examine the nature of the NSI and the relations involved. The epistemology of this research is located within an interpretive paradigm (Grix, 2002:177-180), whose central endeavour is to explore the NSI actors interactions. Figure 7.1-1 illustrates the interrelationship between the building blocks within this research. Farquhar, Ewing and Booth (2011) note that mixed method research brings together quantitative and qualitative research methods from the different research paradigms of positivism and interpretivism. Combining quantitative and qualitative methods in a mixed method approach provides comprehensiveness and greater knowledge yield (O'Cathain, Murphy & Nicholl, 2010).

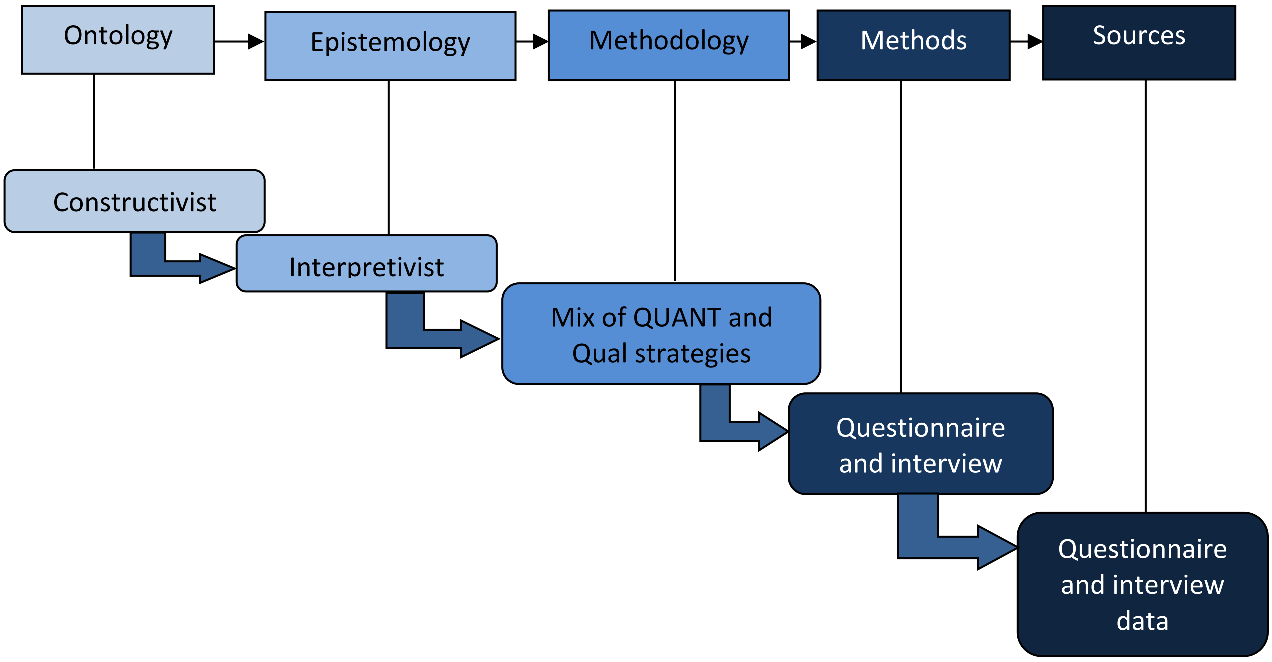


Figure 7.1-1: Interrelationship between the building blocks within this research
Source: Adapted from Grix (2002:180)

It is noted that although philosophical ideas remain largely hidden in research, philosophy influences the practice of research and should therefore be identified as advocated by Tashakkori and Teddlie (2003:700). To describe philosophical ideas, Creswell (2009:6) uses the term 'worldview' to mean "a *basic set of beliefs that guide action*" (Guba & Lincoln, 2005:194). Creswell (2009:6) further discusses four different worldviews: post positivism, constructivism, and advocacy/participatory and pragmatism. From this research perspective, "substantive issues come before methodological and paradigmatic issues" (Punch, 2009:291). Therefore, the pragmatic worldview offers an important feature of focusing on "what works" in getting research questions answered (Tashakkori & Teddlie, 2003:713). Using basic, analytical (strategic) and experimental research classification, this research can be classified as strategic because the purpose is to develop a framework and provide recommendations for strengthening NSI actors' partnerships.

The research adopts a pragmatic approach because mixed methods designs can provide pragmatic advantages when exploring complex research questions. The pragmatic approach has been selected as it sheds light on how research approaches can be mixed fruitfully to offer the best opportunities for addressing research questions. Pragmatism also provides a philosophical basis for a mixed method research as it is not committed to any one system of philosophy and reality and the philosophy does not see the world as an absolute unity (Morgan, 2007). In support, Hammerman (2000:34) posits that pragmatism tends to be less conformist in terms of methods and preconceptions about theory and methods. As a result, pragmatism is more oriented to practical research results and outcomes. Pragmatism, as a worldview, arises out of actions, situations and consequences, rather than antecedent conditions (Bazeley, 2004:141-156; Creswell, 2009:10). In the pragmatic paradigm the scientific method, by itself, is insufficient and rather, common sense and practical thinking are used to determine the best approach (for example, quantitative or qualitative), depending on the purpose of the research and contextual factors (McMillan & Schumacher, 2011:6). Therefore, pragmatism provides the theoretical basis for conducting this mixed-method research.

7.2 MIXED METHOD DESIGN

Based on the proposed research questions, a mixed methods approach was adopted. An analysis of over twenty definitions reveals a strong agreement that mixed research involves the application of both quantitative and qualitative methods within a single research. Mixed method is well supported by researchers such as Ivankova, Creswell and Plano-Clark (2007), Johnson, Onwuegbuzie and Turner, (2007), Creswell and Plano-Clark (2011), Creswell (2009). Ivankova et al. (2007:3) justify the use of a combination of methods by arguing that "the rationale for mixing both kinds of data within one research is grounded in the fact that neither quantitative nor qualitative methods are sufficient, by themselves, to capture the trends and details of a situation". Bazeley (2004) argues that mixed methods research has regained not just acceptability, but popularity, with a significant number of studies emphasising its virtues in terms of greater validation of results. Johnson et al. (2007:112-129) recognise mixed methods research as a third research paradigm that offers an important approach for generating research questions and offering techniques closer to actual practice. In support of mixed methods research, Onwuegbuzie and Johnson (2004:18) recognise: "the fundamental principle … that achieve complementary strengths and non-overlapping weaknesses".

Tashakkori and Teddlie (2003:356) define mixed method studies as combining "qualitative and quantitative approaches into the research methodology of a single study or multi-phased study", while Onwuegbuzie and Johnson (2004:358) define mixed methods research as "a research class where the researcher combines quantitative and qualitative research techniques, methods, concepts or language in a single study". According to Ivankova et al. (2007:263) the selection and implementation of the mixed methods procedures depends on the purpose of the research because "a mixed methods approach has its set of procedures related to the collection, analysis and mixing the quantitative and qualitative data within a study". Table 7.2-1: outlines Greene's five purposes of mixing methods (Greene, 2007), which illustrates different ways in which mixed methods can contribute to the development and evaluation of the construct of SD through research in the NSI.

Table 7.2-1: Five purposes of mixing methods

FIVE PURPOSES OF MIXING METHODS	
1) Triangulation	Where different methods used to measure the same phenomenon, to increase confidence in conclusions reached – if consistent or convergent conclusions are reached.
2) Complementarity	Where methods are used to investigate different aspects or dimensions of the same phenomena to deepen or broaden the interpretations and conclusions from a study.
3) Development	Where results from one method are used to inform the development of other method for example, instrument development, but also sampling and implementation.
4) Initiation	Where different methods are used to investigate different aspects or dimensions of same phenomenon but, in contrast to complementarity, the intention is divergence in order to generate new understandings.
5) Expansion	Where different methods are used to assess different phenomena to expand the scope and range of study.

Source: Greene (2007:34)

The research commences with an open-ended questionnaire followed by open-ended interviews to collect detailed views from selected participants. The two approaches were combined to provide an in-depth overview of HEIs landscape within the NSI. Ivankova et al. (2007:206) state that "a study that employs mixed methods approach would be the use of a survey to first establish attitudes of participants towards a topic and then follow up with in-depth interviews to learn about individual perspective on this topic". Scholars in mixed method research such as Creswell (2009), Ivankova et al. (2007), Punch (2009) and McMillan and Schumacher (2011) provide the following classification of mixed methods research designs:

The triangulation design: this involves concurrent, but separate, collection and analysis of the two types of data which are then merged either at the data transformation stage or at the results interpretation stage.

The embedded design: This design is used when the researcher needs to answer a secondary research question that is different from, but related to, the primary research question by playing a supportive secondary role. The design can be one or two-phase in the sense that the two sets of data may be collected at the same time or sequentially.

The exploratory design: It involves a two-phase mixed methods research design where qualitative data collection precedes the quantitative ones. The use of focus groups and/or individual interviews followed by a second phase that uses a large scale quantitative survey is an example of exploratory design.

The explanatory design: It is a two-phase mixed methods research design using qualitative data to help explain and clarify initial quantitative data. Conducting a large scale survey followed by a second phase qualitative study with in-depth interviews to selected sub-samples, in order to gain a fuller understanding of the phenomenon being studied is an example of explanatory design.

In the chosen pragmatic approach, this research adopts a sequential design (one type of analysis, informing the other) "QUANT" (QUANT → QUAL) QUANTITATIVE → QUALITATIVE indicates quantitative, while "QUAL" indicates qualitative (Creswell, 2009:209) (Figure 7.2-1).

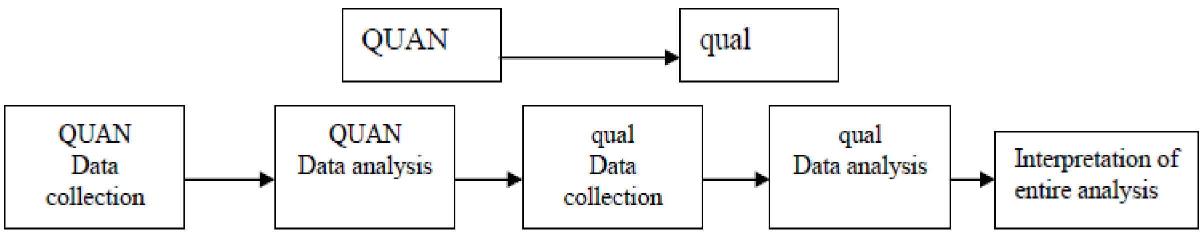


Figure 7.2-1: Explanatory sequential design used
Source: Adapted from Creswell (2009:209)

In order to generalise results to a population the first phase of the sequence consists of a survey and the second phase consists of an illuminative case study where qualitative data is collected by means of open-ended interviews that enable collection of detailed views from a selected willing Heads of Research Units in Universities.

7.3 RESEARCH PARTICIPANTS

In this research, the relevant population was made up of the HEIs, which consists of twenty three universities classified into three groups: eleven traditional/conventional research oriented universities offering discipline-based degrees, six universities of technology focusing on career-orientated and professional programmes, six universities of technology and six comprehensive (or dual) universities combining both roles. The Frascati Manual (OECD, 2002b:77) describes the higher education sector as comprising "all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions". The questionnaire targeted the Vice Chancellors (VCs) of Research, Deans of Research and Directors of Innovation Centres. According to Monette, Sullivan and Dejong (2008:130), a population is the entity from which the sample is extracted for the purpose of undertaking a research. Monette et al. (2008:130) further note that a sample is "drawn from a population, and refers to all possible cases of what one is interested in studying". Strydom (2005:194) defines the notion as follows "a population is the totality of persons, events, organisation units, cases records or other sampling units with which the research problem is concerned." Bless and Higson-Smith, (2000:85) define a population as "the set of elements that the research focuses upon and to which the obtained results should be generalised". Fraenkel and Wallen (2007:92) state that "one of the most important steps in the research process in the selection of the sample of individuals who will participate either by being observed or questioned."

Scholars such as Fraenkel and Wallen (2007), Monette et al. (2008), Creswell (2009) and Punch (2009) classify sampling methods into two categories, namely: probability and non-probability sampling methods. The first category includes the simple random, systematic, stratified and cluster samplings, while the second comprises convenience, quota, snowball and purposive or judgemental sampling. Sampling is concerned with drawing individuals or entities from a population in such a way as to permit generalisation about the phenomena of interest from the sample to the population, while data collection describes the specifics of gathering the data (Fraenkel and Wallen, 2007). This research used a purposeful sampling technique, where inferences were then made to the population within a relationship, illustrated in Figure 7.3-1:

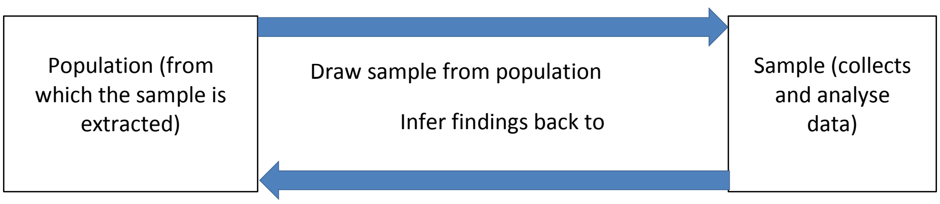


Figure 7.3-1: Population and sample
Source: Adapted from Punch (2009:251)

Miles and Huberman (1994:27) state that "you cannot research everyone, everywhere, doing everything" while Monette et al. (2008:130) are of the view that "we can get better information from carefully drawn samples than we can from an entire group". According to Monette et al. (2008:148), "investigators use their judgment and prior knowledge to choose for sample people who best serve the purpose of the research". Applying a purposive sampling approach, despite all efforts, out of the twenty three HEIs, twelve Heads of Research Institutions agreed to participate in this research. The majority of contacts obtained referred to individuals in senior positions such as

VCs of Research, Research Directors, Deans or other senior Research management-level positions. Where individuals other than Research VCs, research Directors and Deans were contacted, the questionnaire requested that these persons work through the research VC's office to ensure an institutional, rather than a personal response was provided. This was done in order to ensure that appropriate, well-informed individuals were charged with providing the data. As the researcher was required to obtain consent from willing participants beforehand as part of ethical clearance procedure, convenience sampling was employed which, according to Ivankova et al. (2007) consists of selecting the individuals who are willing to participate in the research.

Ivankova et al. (2007:44) identify five types of qualitative data that can be collected in relation to exploring the central phenomenon, namely: (i) observations through which notes and pictures are taken by the researcher during the observation, (ii) individual and focus group interviews resulting in transcripts of interviews with the participants, (iii) artefacts such as materials used by particular group of people (iv) documents including public and/or private records about the studied phenomenon, and (v) audio-visual materials including pictures or audio recordings of people, places or events. This research entails data collection by means of primary individual interviews and secondary publically available documents.

The qualitative aspect of the research aimed at seeking more in-depth explanation of findings from the questionnaire. The study the interview schedule was developed in the light of the data and findings from the quantitative phase in respect of the design of the research which was explanatory sequential mixed methods research design.

7.4 DATA COLLECTION INSTRUMENT: QUESTIONNAIRE

The nature and the design of the research determine the type of data to be collected and the instruments to be used. Mixed methods research requires the collection of both quantitative and qualitative data. Quantitative data involves the use of a survey consisting of questionnaires.

The questionnaire sets out to describe and interpret "what is?" Dörnyei (2003:13) points out that the popularity of a questionnaire includes its ease to construct, extreme versatility and unique capability of gathering a large amount of information quickly in a form that can be processed readily. Dörnyei (2003:14) further argues that "a typical questionnaire is a highly structured data collection instrument, with most items either asking about very specific pieces of information or giving various response options for the respondent to choose from, making the questionnaire data particularly suited for quantitative, statistical analysis".

Monette et al. (2008:35-36) identify two basic categories of questions used in a questionnaire, namely: open-ended and closed-ended questions. This research used open-ended questionnaire in order to avoid leading questions. It was designed to collect narrative responses, as shown in Table 7.4-1. These types of questions are useful for obtaining in-depth information on facts, opinions, attitudes and suggestions or sensitive issues (University of Wilsconsin, 2004). The use of open-ended questionnaire on the various constructs such as innovation, NSI and SD that are part of this research has been, on many occasions, undertaken by the OECD Country Studies. Other innovation and NSI comparative studies that have used open-ended questions, followed by focus groups or interviews include Arnold and Boekholt (2002), Mothe (2001) and Breznitz et al. (2011). In order to collect extensive background material involving "evaluation of the Finnish National Innovation System-Full Report" by scholars such as Aiginger et al. (2009); Edquist et al. (2009) entailed a mix of open-ended questionnaire and panel discussions. Completely open-ended questions allow the researcher to probe more deeply into issues, thus providing new insights, bringing to light new examples or illustrations and allowing for different interpretations and a variety of responses (Sherri, 2008).

Table 7.4-1: Advantages and disadvantages of open-ended questions

	OPEN-ENDED QUESTIONS	CLOSED," OR "FORCED-CHOICE" QUESTIONS
Advantages	• Allow respondents to answer in their own words. • Answers are not forced. • Helpful to explore things for which you do not yet have a hypothesis or theory. • Provide more "richness" or "depth" in your data (for example may help you explore "why" in more detail). • Can help you identify possible responses options for further quantitative research.	• Easier to code. • Allow for statistical summaries of large number of cases. • If question is well-constructed, can provide more clear-cut categories to measure knowledge, skill, attitude, or behavior. • Reporting results may be more straightforward.
Disadvantages	• More complex to code. • More difficult to make clear-cut comparisons between responses. • Respondents with strong positive or negative opinions may choose to take the time to answer. Those with neutral but important observations may not answer. • Stronger role of data interpretation and analysis required.	• Risk influencing responses by forcing choices. • Order of options can affect results. • Possible response options may be omitted. • "Other" or "none of the above" response options are not always informative.

Source: University of Wilsconsin (2004:2)

The two-phased approach provided this research with the opportunity to review and analyse the questionnaire results and tailor the subsequent in-depth interview instrument to follow-up on significant or confusing responses. This iterative analytic approach also simplified subsequent attempts to integrate the coded qualitative data collected in in-depth interviews with questionnaire data.

Dörnyei, (2003:8) classifies the questionnaire into three types of questions, with each falling into the three broad categories, as follows:

(i) Factual questions (also called classification questions): These seek to establish the respondent's demographic characteristics or any other relevant background information relevant in interpreting the responses.

(ii) Behavioural questions: These questions seek to establish the respondents' life-styles, actions, habits and history. The second category of questions dominated the questionnaire and was aimed at determining the research organisation's research 'historical" information.

(iii) Attitudinal questions: This category concerns respondents' opinions, interests, attitudes, values and beliefs. More of this out of the third category questions were utilised in conjunction with the second category questions.

According to McMillan and Schumacher (2011:195), questionnaires can use statements or questions, but in all cases, the subject is responding to something written for specific purposes. Figure 7.4-1 guided the questionnaire construction process.

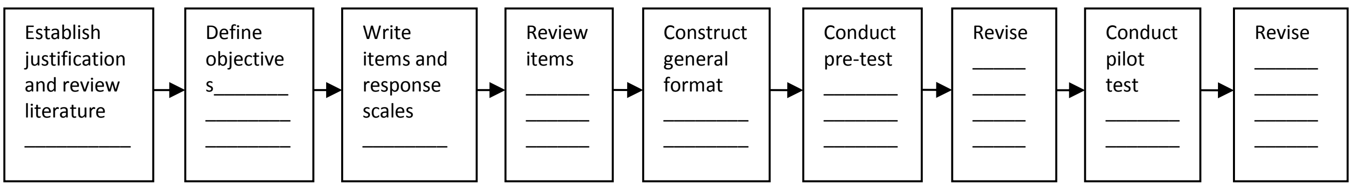


Figure 7.4-1: Steps in developing a questionnaire
Source: Cohen, Manion and Morisson (2010:195)

According to McMillan and Schumacher (2011:197), everything about the questionnaire should be piloted, nothing should be excluded not even the type face (font), testing the questionnaire in its totality. Pre-testing included consulting experts with regard to their perceptions and views of the draft questionnaire and sending the questionnaire to a small sample of units.

Factor analysis was undertaken in the questionnaire development process because literature shows that long surveys produce lower response rates compared to shorter ones. Factor analysis is a mathematical procedure that is useful in reducing a large amount of data, by seeking patterns of relationship among many variables with the objective of discovering something about the nature of the underlying factor that affects all of them (Fink, 2003:18).

A self-administered MS Word research questionnaire was sent via email to potential participants. A self-administered questionnaire tends to be more reliable because of anonymity provided, thereby encouraging greater honesty and is economical in terms of time and travel cost reduction by mailing the questionnaire (Cohen et al., 2010:133). Furthermore, with the aid of computer software, data processing can be straightforward and efficient for a well-constructed questionnaire. Besides being cost effective, a questionnaire is versatile. Research shows significantly lower levels of missing or incomplete data with online responses compared with the paper/pencil method (Creswell, 2009:146). Issues such as missing data or skipped responses tend to alter the *reliability* of the data (McMillan & Schumacher 2011:199). Also, a more rapid follow-up procedure to improve the sampling rate is realised (Creswell, 2009:146).

Some of the disadvantages of using online questionnaires include the 'risk' of low rate of returns, pilot testing issues, the lack of interaction with the respondents, construction, wording the length appropriateness for the targeted sample, as well issues of processing and administration (Creswell, 2009:146). According to Creswell (2009:146-147) despite questionnaires gaining popularity among researchers, some weaknesses of questionnaires include:

(i) The simplicity and superficiality of answers: Efforts have been made to develop questions items that were simple, straightforward and comprehensible by the respondents.

(ii) Unreliable and unmotivated respondents: For many people, not being very thorough in a research sense especially when there is no benefit from the research in anyway results may vary.

(iii) Respondent literacy problems: The problem was not encountered because the research was targeting key research heads.

(iv) Little or no opportunity to correct the respondents' mistakes: a 'risk' factor because of no contact between the researcher and the respondent, the problem was minimised by pilot testing the questionnaires.

(v) Bias such as social desirability or prestige bias, self-deception, acquiescence bias, Halo effect, as well as fatigue effects. The biases were taken into consideration during the questionnaire construction process and efforts made to minimise them.

Even though there is no single recipe yet available for minimising the effect of the potential problems associated with self-completed questionnaire, precautions, effort and skills were applied in minimising the above listed weaknesses.

According to McMillan and Schumacher (2011:150), measurement scales refer to the properties that describe the relationships among numbers. Four measurement scales: nominal, ordinal, interval, and ratio which will be considered:

- **Nominal**: Implies name, which describes the scale, such as classification on the basis of gender (male or female) (McMillan & Schumacher, 2011:150).
- **Ordinal**: Example ranking innovative ideas from most important to least important on a left to right spectrum with given labels "0, 1, 2, 3,4, 5"; Likert scales are used to rank on a scale of "1 to 5" the degree of satisfaction (McMillan & Schumacher, 2011:150).
- **Interval**: refers to a type of measurement scale in which numbers are rank ordered with equal intervals between ranks, but where there is no absolute (or natural) zero point. Examples include temperature scales (Fahrenheit, Centigrade) and dates.
- **Ratio**: embraces the main features of the previous three scales – classification, order and an equal interval metric – but adds a fourth, powerful feature: a true zero, which will enable the researcher to determine proportions easily – 'twice as many as', 'half as many as'. 'Three times and, 'measures of distance, money in the bank, time spent on an innovation project, years of research, income, are ratio measures are capable of having a 'true' zero quantity (Cohen et al., 2010:502).

7.5 DATA COLLECTION INSTRUMENT: INTERVIEW

The second phase of data collection made use of interviews. Interviews enable both interviewers and interviewees to discuss the interpretation of the research topic. Fraenkel and Wallen (2007) and Punch (2009) support the interview as the most predominant and prominent mode of data collection in qualitative research because interviews provide powerful means of understanding the research participants' and offers an opportunity for the researcher to access the research participants' perceptions, definitions and meanings of situations as well as constructions of reality. In this research, in-depth, semi structured-interviews consisted of questions intended to explore and examine particularly ambiguous or interesting questionnaire responses as well as standard questions exploring general perspectives of the respondent institutions on the purpose and future of research commercialisation for SD in South Africa.

According to Bogdan and Biklen (1992:34), an interview is useful in gathering descriptive data in the research participants' own words so that the researcher can develop insights on how participants interpret the phenomenon. Nieuwenhuis (2007:70) defines an interview as a two-way conversation in which the interviewer asks the participant questions to collect data and to learn about the ideas, beliefs, views, opinions and behaviours.

Fraenkel and Wallen (2007), Monette et al. (2008), Punch (2009) and Cohen et al. (2010) suggest a variety of interview types, ranging from open-ended interview to the semi-structured and closed interviews, which can be classified structurally on a continuum of structured to unstructured interviews. In a structured interview, the responses are fixed and respondents select from among fixed sets of responses, whereby standardisation is maximised, while variation and flexibility are minimised. A structured interview entails the development of pre-set response categories, which act as a schedule or guide in the use of pre-established and questions.

According to Punch (2009:21), an unstructured interview can be described as a non-standardised, in-depth and open-ended interview, which normally takes longer in the form of conversation where the research participant provides insight into the event or phenomenon under research. Fraenkel and Wallen (2007:35-40) and Punch (2009:22) view unstructured interview as a powerful data collection tool capable of producing valuable and rich data for exploring the research participants' meaning and interpretations of situations and events, as opposed to the structured interview.

Cohen et al. (2010:218-220) and Creswell (2009:183-184) have identified a number of ways of conducting qualitative interviews, namely: face-to-face, telephonic, and focus group interviews. Whatever interview format is adopted, Creswell (2009:183) cautions that the interview is a social, interpersonal encounter and not merely a data collection exercise, which requires precautions and care mostly by the researcher.

In order to gain more detailed picture of research participants on a number of issues that emerged from the quantitative research phase of this research in conjunction with the research design, a semi-structured face-to-face interview was used. An online interview with the aid of Skype software was conducted. A set of predetermined open-ended interview questions guided the online sessions, where both the researcher and participants were flexible, enabling the researcher to gain clarity and make follow-ups on particular emerging issues.

7.6 SECONDARY DATA COLLECTION

Though interviews and a questionnaire provided this research with relevant data about the research institutions, secondary data were used to supplement the data collected and also to verify the accuracy of data provided. Secondary data, as a third data collection tool, was used because the research was based on the assumption that some research institutions may lay claim to research performance and innovation activities, while not necessarily doing so in practical terms.

Secondary data collection has a long tradition in the social sciences, and has been extensively employed in research (Punch, 2009:260). Secondary data collection methods enable the researcher to gain a deeper insight and comprehension of the phenomenon under research (Nieuwenhuis, 2007:90). The distinctive feature of secondary data is that it offers the researcher opportunity to gather data from publicly available sources, rather than relying on research participants' accounts (Cohen et al., 2010). Creswell (2009:149) suggests a number of activities and considerations for the researcher when collecting secondary data, including ethics, selecting relevant documents, deciding what and when to collect and analysis of the findings.

Without the use of available theories and frameworks in SD in South Africa through research in the NSI, collection of secondary data and analysis might have been undisciplined and pattern matching impossible. The key to the study design is the detailed and prior development of the conflicting theoretical patterns and mechanisms against which the actual data was compared. The approach to case study mimics that which is frequently used in experimental science, where expert knowledge of prior research and careful hypothesis development precede actual experimentation.

The use of secondary data was justified by considering the mixed methods sequential design adopted. The secondary data enabled the researcher to obtain more details about aspects that were pointed out or expressed in the survey as well as from interviews, but needing further investigation and confirmation. Secondary data collection was, therefore, fitting with the research objectives, offering an opportunity to look afresh at facts that might have been taken for granted and provided a reality check on issues gone unnoticed or unexpected (Cohen et al., 2010; Fraenkel & Wallen, 2007; Nieuwenhuis, 2007; Punch, 2009).

Collecting secondary data involved undertaking a desktop study of the contemporary NSI landscape and, in particular, an assessment of: (i) the OECD Review and its recommendations; (ii) key policies, strategies and reports of the DST and its public entities including the science councils and the national facilities (particularly in the period 2004-2009; and (iii) the role of the private sector in STI.

Secondary data were collected from various legislative and policy documents in South Africa, which included (i) The White Paper on Science and Technology (1996); (ii) the South African NSI Country Review Report by the Organisation for Economic Cooperation and Development (OECD), (2007b) (iii) the New Growth Path Framework (South African Department of Economic Development (EDD), 2010); (iv) the Diagnostic report by South African National Planning Commission (NPC) (2011a), National Development Plan: Vision 2030 by the NPC (2011b); (v) The South African National Commission on Higher Education (1996); (vi) The South African National Commission on Higher Education (1996); and (vii) The SA DST Ministerial Review Committee (2012).

International policy documents also informed the research such as human development indices (HDI) by the UNDP, World Economic Forum (WEF), Global Adaption Institute (GAIN), Environmental Performance Index (EPI), the ecological footprint, World Bank's Worldwide Governance Indicators Framework and International Labour Organisation's Decent Work initiative.

7.7 QUANTITATIVE DATA COLLECTION

Quantitative data were collected by means of a survey questionnaire (Appendix 3) which was administered to a purposeful sample of twelve Heads of Research. According to McMillan and Schumacher (2011:196), "questionnaires do not emerge fully-fledged, they have to be created or adapted, fashioned and developed to maturity after many abortive test flights and every aspect of a survey has to be tried out beforehand to make sure that it would work as intended."

7.8 QUALITATIVE DATA COLLECTION

The phase of the sequential design relates to qualitative data collection by means of semi-structured one-to-one interviews with purposefully selected Heads of Research (Appendix 4). All interviews took place at a time agreed upon between the researcher and Heads of Research institutions. The set of predetermined questions guided the open-ended interviews.

Fraenkel and Wallen (2007:458-459) point out the following important practices required during an interview: (i) neutrality as possible to avoid deception in any form; (ii) respect the individual being interviewed; (iii) develop an appropriate rapport with the participant; (iv) ask the same question in different ways when it appears necessary; (v) ask the interviewee to repeat an answer or a statement when there is some doubt about the completeness of a remark; and (vi) avoid leading questions.

7.9 DATA ANALYSIS PROCEDURE

This research used a combination of the seven phases of the mixed method analysis process proposed by Onwuegbuzie and Teddlie (2003:351-356), summarised in Table 7.9-1.

Table 7.9-1: Phases of the mixed method analysis process

PHASES OF THE MIXED METHOD ANALYSIS PROCESS	
1) Data reduction	For example, quantitative data analysed using descriptive statistics and qualitative data are categorised as descriptive themes.
2) Data display	For example, data from both sources are organised and presented visually in graphs and matrices.
3) Data transformation	Quantitative data are converted or 'qualitised' into narrative codes that can be analysed using qualitative techniques and qualitative data are converted or 'quantitised' into numerical codes and analysed using quantitative techniques.
4) Data correlation	Correlating quantitative data with qualitative data, or vice versa.
5) Data consolidation	Different data types merged into one dataset.
6) Data comparison	Comparing data from two different sources.
7) Data integration	Integrating quantitative and qualitative data into one coherent whole that will be analysed and interpreted simultaneously as a single dataset or two datasets (quantitative and qualitative)to be analysed separately.

Source: Collated from Onwuegbuzie and Teddlie (2003:351-356)

In general, a non-linear "input-output" data analysis and evaluation framework (Figure 7.9-1) was utilised to classify and organise data on the construct of sustainable development as a consequence of commercialisation of research in the NSI and the impacts of policy and governance instruments. The framework takes into account intended policies and activities as well as contextual factors and unforeseen events in the analysis of the causalities of institutions and policies.

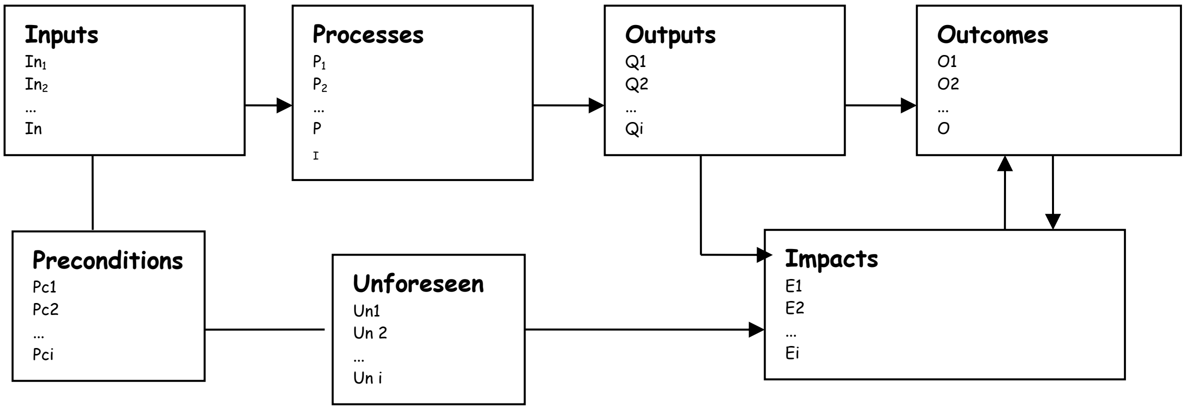


Figure 7.9-1: "Input-Output" data analysis and evaluation framework
Source: Adapted from Dunn (2003:19)

According to Onwuegbuzie and Teddlie (2003:351), "the point at which the data analysis begins and ends depends on the type of data collected, which in turn depends on the sample size, which in turns depends on the research design, which in turn depends on the research purpose". The sequential mixed research data collection was followed by both descriptive data analysis with inference discussion on the entire population.

Descriptive research, according to Creswell (2009:209), is concerned with "…how, what is or what exists is related to some preceding event that has influenced or affected a present condition or event". Descriptive statistics describe and present data, for example, in terms of summary frequencies (Cohen et al., 2010:503). Descriptive analysis has been applied to describe the statistical units in terms of innovative or non-innovative activities without drawing any conclusions (no generalisation) about the underlying survey or target population (OECD & Eurostat, 2005). Inferential statistics, by contrast, strive to make inferences and predictions based on the data gathered (Cohen et al., 2010:504). The objective draws or infers conclusions about the target population (generalisation of results). Data analysis commenced with the reduction of the mass of data gathered in a form that is suitable for analysis in order to facilitate deriving usable meaning from the data. For both qualitative and quantitative data, the process of data reduction was preceded by editing, followed by coding data in preparation for analysis.

Quantitative data from the questionnaire was analysed using SPSS and MS Excel, allowing for data interpretation and framework building with regard to 'SD in South Africa through research in the NSI'. The following process guided the research analysis process (Creswell, 2009:200-202):

Step one involved organising and preparing the data for analysis. Data collected by the means of questionnaire survey was checked for accuracy, completeness, and uniformity of the questionnaire, with the aim of identifying and eliminating errors made by research respondents.
Step two involved reading through the data to get a general sense of the information and to reflect on its overall meaning, general idea, and tone of the ideas and the impression of the overall depth, credibility, and use of information.
Step three involved undertaking a detailed analysis with coding process. Coding is the process of organising material into segments of text before bringing meaning to information. Coding involved taking text data gathered during data collection, segmenting sentences (or paragraphs) into categories, and labelling those categories with a term, often a term based in the actual language of the participant (called an *in vivo* term). The coding process has been used to generate a description of categories and themes for analysis.

As a standard method of capturing interview data, the interviews were audio recorded. The interviews were then transcribed. According to Cohen et al. (2010), transcribing of data is a crucial step, which has the potential for massive data loss, distortion and reduction of complexity. Denscombe (2003:184) emphasises the complexity of transcribing, arguing that "transcription is not a mechanical process of putting tape-recorded talk into written sentences, but that the talk needs to be tidied up and edited a little to put in a format on the written page that is understandable to the reader". Denscombe (2003:185) further points out that although the transcribing process is certainly laborious, it is the most valuable part of the research because it brings the researcher close to the data and is, therefore, recommended to be done by the researcher in order to include some non-verbal cues in the transcripts.

The data entry is followed by the process of data cleaning, which involves carefully examining the data and making any corrections before undertaking the actual statistical procedure (Monette et al., 2008:45). Once the data is sorted and captured, it is important that the researcher gets to know it inside out. The researcher transcribed and carefully re-played the tapes as recommended by Henning, van Rensburg and Smit (2004:19). According to Nieuwenhuis (2007:105), qualitative data comes in many forms and from a variety of sources all producing raw text or narrative data varying from briefs responses to open-ended story telling generated by the process of coding data into analytical units called themes. The themes and categories are utilised during framework development.

In this research, qualitative data analysis involved making sense out of data. Secondary and interview data was subject to qualitative analysis with the aid of NVIVO computer software.

Step five involved the descriptions of presenting the themes in the qualitative narrative, which was undertaken with a detailed discussion of themes (complete subthemes, specific illustrations, multiple perspectives from individuals and quotations) and a discussion with interconnected themes.

Step six, the final step, involves making an interpretation or meaning of the data. Asking "what were the lessons learned?" captures the essence of the idea (Guba & Lincoln, 2005:194). The lessons relate to meaning derived from a comparison of the findings with information gleaned from the literature or theories. Guba and Lincoln (2005) suggest that the findings confirm or diverge from past information. Step six can also suggest new questions that need to be asked – questions raised by the data and analysis that the researcher had not foreseen earlier.

According to Onwuegbuzie and Teddlie (2003:350), interpretation of the data enables the researcher to search for emerging patterns, concepts, associations and data explanation. Creating themes involves engaging in defining concepts, creating typologies, finding associations with data, mapping the range and nature of phenomena, providing explanations or developing strategies. The quantitative findings from data associated with those from qualitative data in a way of generating more meaning and, thereby, enhancing the quality of data interpretation.

7.10 DATA TRIANGULATION

Techniques designed to combine the results of qualitative and quantitative research can provide researchers with more knowledge than separate analysis (O'Cathain et al., 2010). Integration—the interaction or conversation between the qualitative and quantitative components of a study—is an important aspect of mixed methods research, and, indeed, is essential (Farquhar et al., 2011). A lack of integration between components limits the amount of knowledge that these types of studies generate. Without integration, the knowledge yield is equivalent to that from a qualitative study and a quantitative study undertaken independently, rather than achieving a "whole greater than the sum of the parts" (O'Cathain et al., 2010:1147; Farquhar et al., 2011). There is a tendency to analyse and present the findings of the respective methods separately, as stand-alone studies, which limits the value of mixed methodology (O'Cathain et al., 2010:1147). This research used questionnaire and interview methods to examine different aspects of the construct of SD through research within the NSI.

O'Cathain et al. (2010:1147-1150) outline three techniques that may assist researchers to integrate data or findings in mixed methods studies and show how these might enhance knowledge generated from this approach. The three techniques are: (i) triangulation protocol; (ii) following a thread; and (iii) mixed methods matrix shown in Figure 7.10-1.

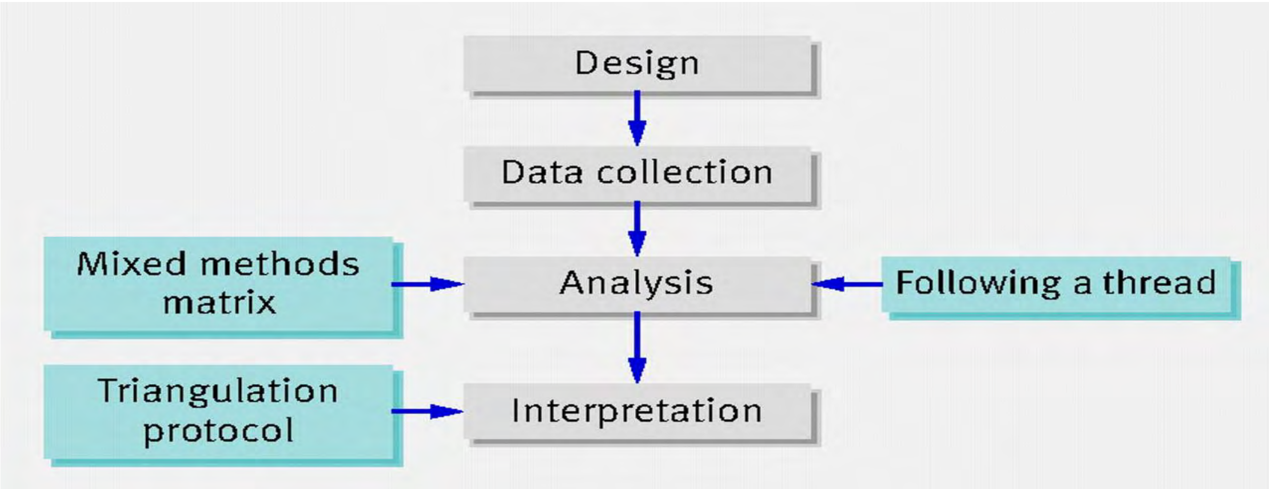


Figure 7.10-1: Point of application for three techniques for integrating mixed methods research
Source: O'Cathain, Murphy and Nicholl (2010:1147)

This research made use of the three techniques. According to Farmer, Robinson, Elliott and Eyles (2006) triangulation protocol, although developed for multiple qualitative methods, is relevant to mixed methods studies. This technique involves producing a "convergence coding matrix" to display findings emerging from each component of a study on the same page. This is followed by consideration of where there is agreement, partial agreement, silence or dissonance between findings from different components. This technique for triangulation is the only one to include silence—where a theme or finding arises from one data set and not another. Silence might be expected because of the strengths of different methods to examine different aspects of a phenomenon.

The triangulation protocol moves researchers from thinking about the findings related to each method to what Farmer et al. (2006) refer to as meta-themes that cut across the findings from different methods. According to Morgan (1998), this "third effort" occurs after analysis of the qualitative and the quantitative components. Triangulation protocol requires the researcher to list the findings from each component of the research on the same page and consider where findings from each method agree (convergence), offer complementary information on the same issue (complementarity), or appear to contradict each other (discrepancy or dissonance) (Erzerberger & Prein, 1997; Farmer et al., 2006). According to Fielding and Fielding (1986), explicitly seeking disagreements between findings from different methods is an important part of the triangulation protocol. Disagreement is not a sign that something is wrong with a study. Exploration of any apparent "inter-method discrepancy" may lead to a better understanding of the research question and a range of approaches have been used within health services research to explore inter-method discrepancy (Fielding & Fielding, 1986; O'Cathain et al., 2010).

Moran-Ellis Alexander, Cronin, Dickinson and Fielding (2006) describe a different technique for integrating the findings from the qualitative and quantitative components of a study, called following a thread, which takes place at the analysis stage of the research process as shown in Figure 7.10-1.

Data from the qualitative and quantitative components can be integrated at the analysis stage of a mixed methods study (Figure 7.10-1). In this research, in-depth interviews were carried out with a sample of survey respondents, creating a subset of cases for which there was both a completed questionnaire and a transcript. All the data collected on a single case were studied together, focusing attention on cases, rather than variables or themes, within the research. The data were examined in detail for each case—for example, comparing the respondent institution's responses to a questionnaire with the interview transcript. The data on each case were also summarised and displayed in a table/matrix as proposed by Creswell and Plano-Clark (20011) along the lines of Miles and Huberman (1994) meta-matrix. Within a mixed methods matrix, the rows represent the cases for which there is both qualitative and quantitative data and the columns display different data collected on each case. The table/matrix allowed the researcher to pay attention to surprises and paradoxes between types of data on a single case and then look for patterns across all cases in a qualitative cross case analysis (Miles & Huberman, 1994; O'Cathain et al., 2010).

7.11 COGNITIVE MAPPING

In this research, cognitive Mapping was used to support framework building and as mental maps of the interrelationships among the categories involved in the construct of SD, which result in commercialisation of researcher in the NSI. The technique enabled the research to structure the complex construct under investigation. According to Hines (2000:11), cognitive mapping is a technique of using an interpretable picture-based view of participants' ideas as well as the interrelationships between these ideas.

Cognitive Mapping was used to summarise and consolidate data and information for the qualitative, quantitative and secondary sources. Cognitive Mapping was also used to provide a holistic picture of the construct under investigation as well as the individual components and their importance. The concepts are not isolated, fragmented ideas, but integral components of a much larger framework and are complementary, connected and interrelated. The topic of discussion was captured at the top of the map in-between arrows to create a central theme. The first of the arrows was used to indicate the multi-dimensional interrelationships among the concepts. The general aim is to identify key concepts presented in the data and to attach codes to those concepts. The process entails uncovering patterns, categories, themes by making careful considerable judgements about what is really meaningful and significant in the data (Patton, 1990:406). The process of Cognitive Mapping was used to indicate interrelatedness of the identified concepts. Cognitive Mapping involved (i) plotting categories (ii) clustering of categories and indicating sub-categories (iii) link concepts through descriptive arrows. Cognitive Mapping was also used to enhance data validity and further contributed to reduce researcher bias.

7.12 ETHICAL ISSUES CONSIDERATIONS

According to Bogdan and Biklen (1992:52), the term ‘ethic’ is often surrounded with hidden meaning, carries emotionally charge and can be referred to in research as principles of right and wrong that a particular group accepts. Cohen et al. (2010:49) further point out those ethical issues can arise early during the research project, as the research progresses or after the research and thereafter “each stage in the research sequence may be a potential source of ethical problems”. All social research constitutes to some extent, people’s lives intrusion, but it is more acute in qualitative research. Punch (2009:50-51) lists ethical issues as falling into three categories, those that arise as: (i) the research progresses including harm and risk, honesty and trust, privacy and intervention and advocacy; (ii) early in the research project including the worthiness of the project, the competence boundaries, the informed consent and the benefits, costs, reciprocity; and (iii) later in or after the project including research integrity and quality, ownership of data and conclusions, and use and misuse of results.

The list of ethical issues in the preceding paragraph is not exhaustive. Regarding the ethical issues, this research complied with the UKZN ethical clearance policy. Ethical clearance was first granted to allow the researcher to undertake the research (Appendix 5). Not only in UKZN, but anywhere else, no researcher should neglect the three fundamental ethical concerns in the field of research dealing with human subjects, namely: protection from harm, informed consent and right to privacy (Bogdan & Biklen, 1994; Fontana & Frey, 2003; Cohen et al., 2010; Fraenkel & Wallen, 2007; Monette et al., 2008:130; Punch, 2009). According to Bogdan and Biklen (1992:34-37), the first ensures subjects are not exposed to risks that are greater than the gains, if any, that might derive, while the second attempts to ensure that subjects enter research voluntarily after a clear understanding of the nature of the research and the dangers and obligations that are involved. The third ethical concern confronts the researcher with the dilemma of whether threats to privacy are warranted by the research. Unfortunately, the right to privacy often is a difficult issue to resolve. According to Monette et al. (2008:56), three major ways of dealing with the problem of protecting participants' privacy are: (1) allowing the research participants edit the transcribed data; (2) keeping the data anonymous, and (3) keeping the data confidential. This research adhered to data research ethics and confidentiality by keeping the data anonymous.

Other ethical issues considered during the entire research process were those of obtaining ethical clearance, confidentiality of data collection and data presentation. According to Monette et al. (2008:132) the informed consent is considered as a central canon of research policy and was sought before any attempt of field work. Informed consent refers to informing potential research participants about all aspects of the research that might reasonably influence the decision to participate in the questionnaire and before each interview. It was explained that all information provided by respondents will be treated confidentially and that respondents could withdraw consent at any time during the research (Cohen et al., 2010; Fink, 2003). Gatekeepers' letters for consent from participants were obtained before undertaking data collection.

7.13 VALIDITY AND RELIABILITY ISSUES

The researcher is concerned about dealing with issues of *validity* and *reliability,* especially being aware that it is very easy to slip into invalidity because invalidity can enter at any stage of a piece of research (Cohen et al., 2010:144). Validity is an important key to effective research, if a piece of research is invalid then it is worthless (Cohen et al., 2010:133). Validity and reliability are two factors which any researcher should be concerned about while designing research, analysing results and judging the quality of the research (Creswell, 2009:142). Validity refers to the truthfulness of findings and conclusions *approximate* of what is reality or truth, and the degree to which explanations are accurate accounts for the validity of design (McMillan & Schumacher, 2011:104).

Denzin and Lincoln (2005) refer to trustworthiness as more appropriate replacement for such a conventional constructs as truthfulness that pertain more to studies of purely quantitative nature. Mixed method researchers adopt the term 'legitimation' (Onwuegbuzie & Johnson, 2004:15-20). The legitimation of the mixed methods research related to many phases of the research process from philosophical issues to inferences drawn and to the value of the study for consumers (Creswell, 2009). Various kinds of validity are considered during the entire research process example include: content, criterion-related, construct, internal, external, face, jury, predictive, consequential, systematic, catalytic, ecological, cultural, descriptive, interpretive, theoretical, and evaluative validity (Cohen et al., 2010:133).

The main four types of design validity illustrated in Figure 7.13-1 were considered in this research. The four types of validity derive from two categories, internal and external, set out by the works of Campbell and Stanley (1963), Cook and Campbell (1979) and Shadish, Cook and Campbell (2002) illustrated in Figure 7.13-1. Reliability refers to the accuracy or precision of an instrument (Shadish et al., 2002); the extent to which the results are similar over different forms of the same instrument or occasions of data collection. In other words, it is the extent to which measures are free from error (McMillan & Schumacher, 2011:179).

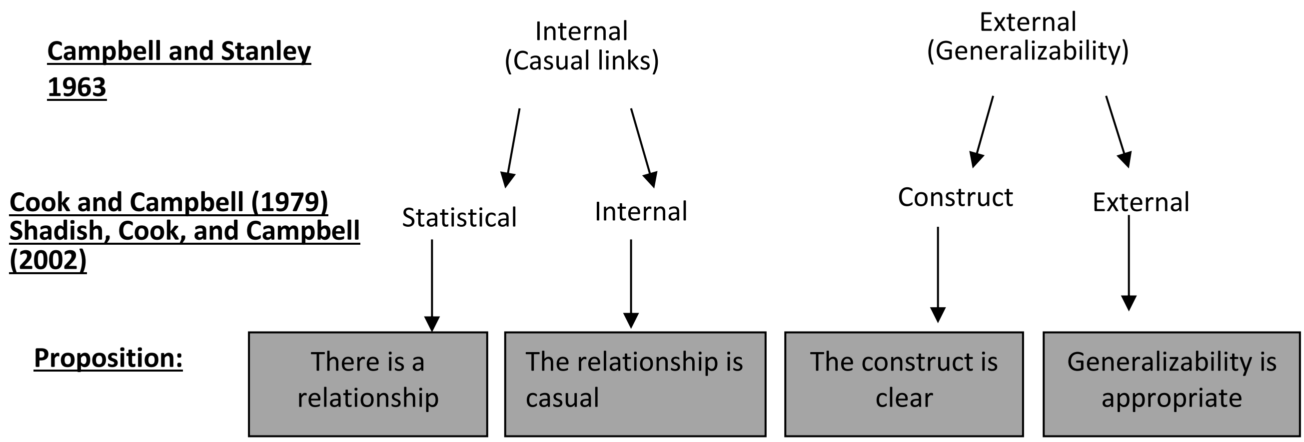


Figure 7.13-1: Types of design validity
Source: McMillan and Schumacher (2011:106)

Researchers in the field of research methodology argue that to establish reliability and validity during research procedures detracts from the subjective nature of the field of qualitative research. Consequently hence the establishment of additional credibility criteria for the research was informed by the literature and secondary data. Prior to the data collection phase, further steps were undertaken, namely: a thorough attention in the data collection instruments development and the pilot-testing of the questionnaire in order to ensure the face and content validity. Also, both population and ecological validities were guaranteed by the range of criteria used in selecting the research participants. However, to deal with the interpretive validity, the researcher relied only on the use of low-inference descriptors in the research report because of the difficulty in obtaining participants consent. Whilst absolute objectivity is an impossible ideal, questionnaire survey methods provides a transparent set of research procedures as to how the information was collected and interpreted (Cohen et al., 2010).

7.14 SUMMARY

This chapter has presented the research design and methodology for examining the construct of SD in South African research commercialisation in the NSI. The chapter presented the quantitative and qualitative data research instruments and data collection methods used as well as the use of secondary data. The research data analysis procedure, data triangulation, the use of cognitive mapping and ethical issues were also examined. The research design has contributed to the growing body of literature in the NSI and more importantly has served as a platform for further research. The study design has been undertaken within a real-life context and provides reasons for adopting the research a mixed method research approach. Any limitation related to this research has been minimised through extensive literature review of the main research concepts and ensuring reliability and validity during the entire research process. The study adopted a pragmatic approach, which consisted of using suitable methods, techniques and procedures suited to the research problem. Having presented the research design, the research moves on to the quantitative and qualitative research analysis.

CHAPTER EIGHT

DATA ANALYSIS AND INTERPRETATION

8. DATA ANALYSIS AND INTERPRETATION

Chapter seven captured the research design used to examine the construct of SD in South Africa, resulting from research commercialisation in the NSI. Chapter Eight presents the research analysis and discussion that will be utilised to identify the main themes for framework construction, research conclusions and recommendations.

8.1 INTRODUCTION

The literature reviews undertaken earlier have informed the chapter. The analysis was conducted in accordance with the questionnaire and interview sections and presented in a table format for ease of comprehension. The five institutions that participated were coded in terms of Institution one to five. Secondary data utilised in this chapter includes the HEIs strategic plans, R&D survey of 2009/10 and publicly available reports which reflect the new higher education landscape in its entirety.

This chapter has assessed the HEIs' research and SD performance, highlighting specific collaborations, strengths and weaknesses and the effectiveness of commercialisation activities within the NSI. The underlying assumption is that the HEIs' performance cannot be adequately assessed outside the specific context of the NSI, to which the institutions belong. Although the NSI is conceived of as a national system, it refers more to the efforts to govern and steer its activities than reflecting the complexities of how innovation, in fact, arises. As in the case of the HEIs, the NSI constitutes a multitude of sub-systems that are geographic, sector or institutional in nature, each of which may be promoted or hindered directly or indirectly.

The chapter is organised as follows: section 8.2 and 8.3 provide an overview of pilot testing and questionnaire layout, respectively. Section 8.4 summarises the questionnaire results, while sections 8.5 to 8.9 convey the main questionnaire results and discussion. Section 8.10 to 8.19 presents the interview results and discussion. Section 8.20 discusses the emerging categories from both the questionnaire and the interview, while section 8.21 is the emerged cognitive map. Section 8.22 comprises the framework that developed from the emerging categories and themes, while section 8.23 is the chapter summary.

8.2 PILOT TESTING

The research questionnaire was administered to a purposeful sample of twelve Heads of Research from South African HEIs. The questionnaire was first pilot-tested using two of the research participants and also submitted to two University of KwaZulu-Natal (UKZN) PhD supervisors. In total, four questionnaire responses were pilot tested.

Pilot-testing is highly recommendable as it serves not only to increase reliability and the validity, but also its practicability Creswell (2009:150). The pilot study enables the researcher to: (i) estimate the required time to complete the questionnaire, (ii) identify repetitive questions and misunderstandings, thus increasing clarity of the questionnaire, and (iii) try out the coding for data analysis (Cohen et al., 2010:390; Strydom, 2005; Dörnyei, 2003:64).

The analysis of the pilot study revealed that the questionnaire was long and in the light of the two respondents' comments, changes were made including reformulation and omission of questions that were found to be unclear to respondents. The pilot-testing experts did not form part of the final research sample. According to Converse and Presser (1986:74-75), pilot-testing is part of the "polishing" or "dress rehearsal" phase that offer an opportunity for cutting, trimming, re-arranging and reformatting the questionnaire. The few suggestions from the pretesting experts and pilot participants were used to improve the questionnaire layout, question response option reformulation, question reformulation and language improvements.

8.3 QUANTITATIVE DATA ANALYSIS (QUESTIONNAIRE)

The questionnaire captured HEIs activities on the construct of SD in South Africa through research in the NSI. It consisted of five sections:

1. The participating institution's demographic profile.
2. The role of research and SD within the HEIs.
3. Measuring effectiveness (barriers and challenges) of research commercialisation within the HEIs.
4. Exploring the nature of interactions between the HEIs and other NSI actors.
5. Establishing the nature of government support, funding and incentives to the HEIs.

8.4 SUMMARY OF RESULTS FROM QUESTIONNAIRE

A questionnaire response rate of 40.0% was achieved from three comprehensive and two traditional universities. Supplementary data sources used for this research purpose included the latest 2009/10 R&D survey and HEIs strategic plans and other documents. The questionnaire was completed by two VCs and three Directors of Research or Innovation Centres. The respondent institutions, which henceforth will be referred to as "the respondent", spanned five provinces in as shown in Table 8.4-1. All the five respondent institutions provided responses to each question. This means the denominator is constant for each finding. The response rate varies from the low 20% to 100% some respondents indicated for example 'commercialisation of research while others did not.

Table 8.4-1: Summary of questionnaire result findings

SUMMARY OF RESULTS		% respondents	No. of respondents
SECTION 1: DEMOGRAPHIC PROFILE			
Has a Deputy VC (or equivalent) in charge of research and industry linkages		100%	5/5
Province	Number of institutions		
Limpopo	1	20%	1/5
North-west	1	20%	1/5
Cape Town	1	20%	1/5
Eastern Cape	2	40%	2/5
SECTION 2: RESEARCH AND SUSTAINABLE DEVELOPMENT ROLE			
• Most common contribution to SD in in terms of the three pillars namely:			
Economic pillar	• Provides competent graduates for development	100%	5/5
	• Charges very low fees	40%	2/5
	• Integrates learning activities in the rural areas and assist the communities for economic development	40%	2/5
	• Supports charity and skills development CE strategy	100%	5/5
Social pillar	• Expansion in the number of strategic partnerships with industries, sector education and training authorities, local and provincial governments, schools, and development agencies.	20%	1/5
	• Close collaboration between the institutional managers working in the CE office.	20%	1/5
	• Enrols students from disadvantaged social backgrounds and trains them to become economically active citizens.	40%	2/5
	• Social role of marine protected areas	20%	1/5
Environmental pillar	• Engage in greening projects and partnerships	100%	5/5
	• Offering programmes on environmental issues	100%	5/5
	• Providing environmental research and policy advice	40%	2/5
Have the policies in SD policies three pillars namely: (economic,	• Two respondent institutions do not have an integrated SD policies in place, have only strategic plans in place	40%	2/5
	• One respondent institution is in the process of developing and implementing separate SD policies	20%	1/5

SUMMARY OF RESULTS		% respondents	No. of respondents
environmental or social role)	in the three pillars namely: economic, environmental or social role.		
	• One respondent institution has put in place a policy framework for responsible resource use and environmental sustainability.	20%	1/5
Most common cited SD challenges	• Difficulties in policies monitoring/implementation	40%	2/5
	• Limited financial resources/Lack of funding	100%	5/5
	• Lack of capacity in terms of human resources skills and knowledge capacity	100%	5/5
	• Poor communication	60%	3/5
	• Lack of [common] purpose and understanding	80%	4/5
	• Resistance to change	40%	2/5
Most common responsibilities of the technology transfer office (TTO):	• Contract negotiation	60%	3/5
	• Student enterprise	100%	5/5
	• Networks	100%	5/5
	• Consultancy	60%	3/5
	• Collaborative research	60%	3/5
	• Licences	60%	3/5
	• Spin-outs/Spin-off	60%	3/5
SECTION 3: EFFECTIVENESS OF RESEARCH COMMERCIALISATION			
HEIs roles in research commercialisation last five years	• Two of the five the respondent institutions have not been involved in research commercialisation.	40%	2/5
	• Three of the five respondent institutions have been involved in research commercialisation.	60%	3/5
Foreseen role of HEIs research in assisting the private sector	• Networking and seeking out external partners	40%	2/5
	• Contract negotiatiator	40%	2/5
	• Managing cooperatives with local business	40%	2/5
	• Develop new technologies for industry	40%	2/5
	• Private sector drive HEIs research/solution-driven	60%	3/5
	• Facilitate collaboration among NSI actors	100%	5/5
	• Consultancy work	40%	2/5
	• Technology Transfer	60%	3/5
	• Knowledge creation, sharing through teach and learning and research ending in publications	40%	2/5
	• Research commercialisation	60%	3/5
Has a dedicated Intellectual Property (IP) office responsible for promoting commercialisation	• Does not have an IP rights office	40%	2/5
	• Very limited role. No internal capacity	20%	1/5
	• Technology Transfer and Innovation Support Office (TTISO) provides a legal and compliance function	20%	1/5
	• Research office is responsible for all external research-related grants and contracts	20%	1/5
Factors for successful commercialisation	• Dedicated staff /HR must be allocated	80%	4/5
	• Strategic planning	40%	2/5
	• Seed funding	40%	2/5
Most commonly reported HEIs collaborations with sectors	• Agriculture and agribusiness	60%	3/5
	• Environmental management	60%	3/5
	• Information communication technology	40%	2/5
	• Engineering for example mechanical and chemical	40%	2/5
SECTION 4: NATIONAL SYSTEM OF INNOVATION ACTORS			
Commonly reported relationship	• Collaborative research	60%	3/5
	• Shared national goals	40%	2/5

SUMMARY OF RESULTS		% respondents	No. of respondents
between HEIS and business and government	• Participate in shaping the national policy and advisory capacity	40%	2/5
	• Standing separately	20%	1/5
Assumed main weaknesses of the relationship between the NSI actors	• Limited financial resources/management	100%	5/5
	• Lack of funding/ Lack of financial support	100%	5/5
	• Lack of collaboration/Lack of networks	80%	4/5
	• Poor communication	60%	3/5
	• Lack of technology and lack of machinery	60%	3/5
	• Lack of purpose	100%	5/5
	• Lack of human resources skills/resistance/ lack of staff with research commercialisation expertise	100%	5/5
	• Difficulty of monitoring/implementation policies	40%	2/5
Suggestions for strengthening the relationship among the NSI	• Should form single research body	20%	1/5
	• Make collaboration compulsory	40%	2/5
	• Formalise the partnerships contractually	20%	1/5
	• Support regional innovation forums, incubators	40%	2/5
SECTION 5: GOVERNMENT SUPPORT, FUNDING AND INCENTIVES			
Major sources of research funding at the HEIS	• Medical Research Council (MRC)	60%	3/5
	• THRIP	100%	5/5
	• National Research Foundation	20%	1/5
	• Eskom	40%	2/5
	• Government subsidy	40%	2/5
	• TIA	40%	2/5
	• Foreign governments	60%	3/5
	• Private funding/industry-commissioned research	80%	4/5
	• Sasol	20%	1/5
	• ARC	20%	1/5
	• WRC	20%	1/5
Government support in facilitating research commercialisation	• Funding	60%	3/5
	• NSI partnerships roles	40%	2/5
	• Policy development	40%	2/5
	• Providing workshops /forum	40%	2/5
	• Technology transfer	20%	1/5
	• Monitoring and evaluation	20%	1/5
	• Commissioning research	20%	1/5

8.5 SECTION 1: RESPONDENT INSTITUTIONS' BACKGROUND

<u>Provide a brief institutional research historical background</u>

The core activities of the five HEIs revolve around three overlapping missions or mandates: teaching (undergraduate and postgraduate degrees), research (mid-to-long term) and community engagement (CE) activities. All the respondent institutions have undergone either merger and/or restructuring, which require efforts to promote post-merger integration. The HEIs are undertaking research, which is however, limited as most academics are undertaking masters and doctoral

Studies. Therefore the HEIs mainly focus on teaching and learning and, to some extent, CE. Figure 8.5-1 is an illustration of the research historical development of one of the HEIs.

Figure 8.5-1 shows that the respondent institution has since 1988 made progress and transitioned from a tuition-based university with uncoordinated research into a balanced tuition-learning, research university, with positive incremental progress projected into 2015. The institution's vision is to achieve "…balance between Research/Innovation and Teaching/Learning …" A time allocation target was established (the 40:40:20 ideal for learning: research: other was presented), and the HEI introduced a system of performance contracts, the post-doctoral programme was established, innovation activities were strengthened, research and innovation incentives were created and executive and senior managers were appointed to focus on research and innovation.

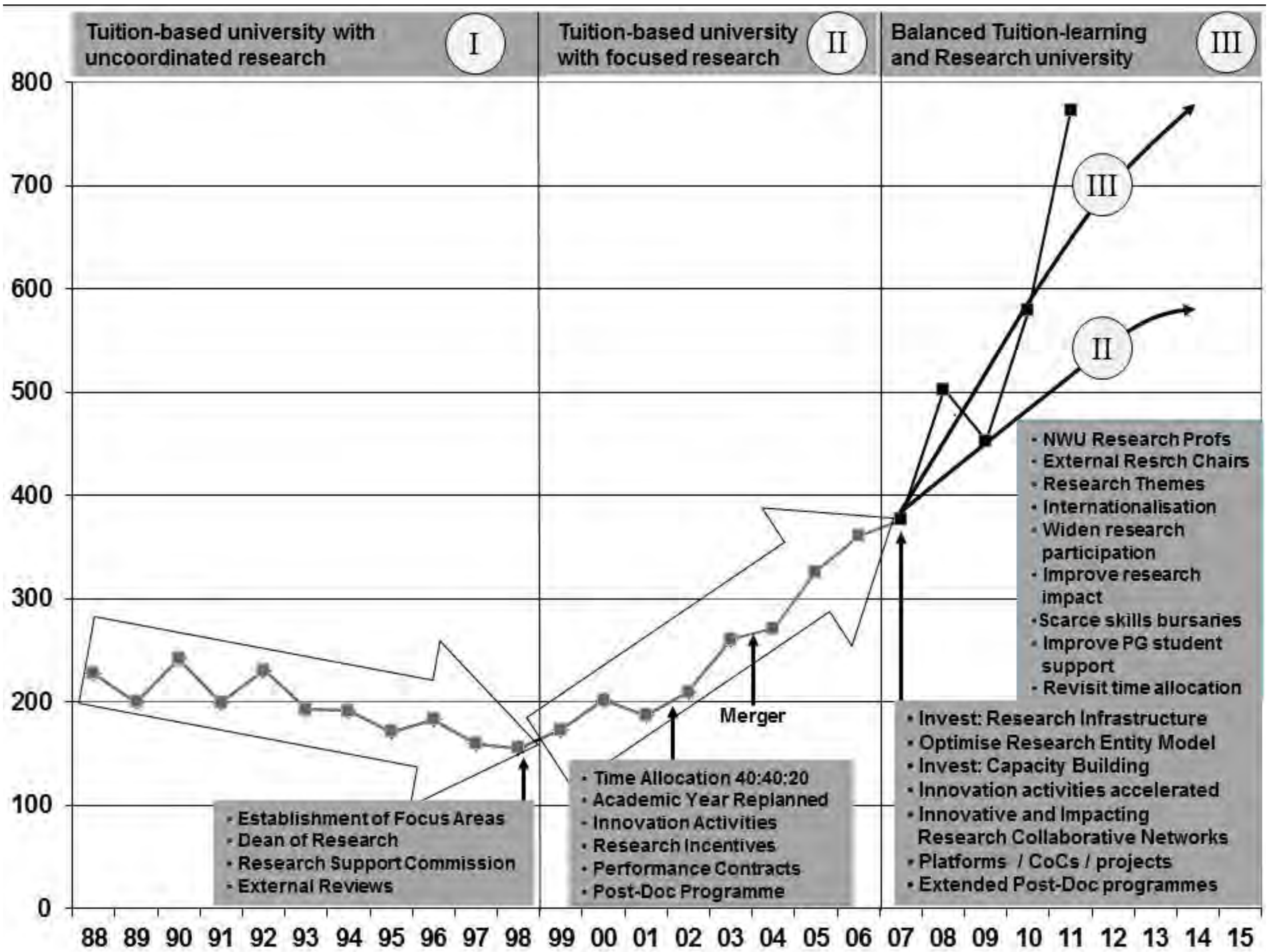


Figure 8.5-1: Research historical development of respondent institution five

Discussion

The defined research and innovation mission of most South African HEIs is to develop and maintain high-quality, relevant and focused research, aligned with national priorities, supplying innovative solutions to challenges faced by the scholarly community, the country, the African continent and the global context.

The public HEIs landscape in South Africa has experienced significant changes between 2003 and 2005 with the merging and restructuring of institutions and the introduction of traditional universities and universities of technology. However, major anticipated post-merger changes can be achieved through coordination, agenda-setting and prioritisation of HEIs research in alignment with the current South African policy documents.

One of the respondents stated that the HEIs have "achieved the formal merger but the qualitative and strategic issues have not yet been resolved, therefore a good synergy is required to entertain multiple and relevant missions". The historical legacy of the colleges, campuses and faculties acts as a barrier, notwithstanding the acceptance (post-merger) of a 'research-based ethos'. The strategic plans and framework for the post-merger HEIs aim at addressing this research deficit facing the institutions. However, the high student–staff ratio creates insurmountable challenges.

At the regional/provincial and local levels in South Africa, there seems to be an enormous disconnect in terms of the opportunities brought by the merger. The government is facing serious capacity issues in terms of resources and political willingness, which have resulted in the lack of a coherent policy framework for the NSI. The 2004 HEIs' merger and reconfiguration that followed have challenged some of the traditional internal boundaries (silos) between disciplinary fields and have also 'forced' individual' institutions to integrate their efforts. However, major post-merger, post-reconfiguration challenges still remain, which are exacerbated by differences across the various geographical locations of campuses and colleges.

8.6 SECTION 2: ROLE: RESEARCH AND SUSTAINABLE DEVELOPMENT

How does your institution contribute to sustainable development in South Africa in terms of the three pillars (economic, environmental or social role)?

Contribution to SD pillars, namely: economic, environmental and social by the five respondents is shown in Table 8.6-1. Data analysis indicates that the HEIs have been contributing to SD in South Africa with reference to the three pillars.

Table 8.6-1: Respondent institutions contribution to sustainable development

HEIS	ECONOMIC PILLAR	SOCIAL PILLAR	ENVIRONMENTAL PILLAR
1	The institution provides competent graduates (using low fees) who become employed and contribute to the economic development of the country	The institution enrols students from disadvantaged social backgrounds and trains them to become economically active citizens and make positive contribution	Saving the environment is an objective to the institution, as the students engage in greening projects.
2	The institution charges low fees, with a students' high percentage from previously disadvantaged and work-integrated learning activities in rural areas and assist in problem-based learning	Offers various programmes that serve societies. Since it is based in the rural areas, it tries to assist the societies in terms of promoting business-related programmes that promote entrepreneurial spirit	The institution offers some programmes that are environmentally friendly in order to cater for the needs of the societies
3	The institution officially sees its CE role as contributing to SD and CE strategy accordingly	Community Development Trust has a major focus on SD facilitating fund and governance of social entrepreneurs who execute projects impacting on the triple -bottom-line	In 2011 the institution conducted a base-line needs and resource assessment in the province to be updated in 2014
4	The institution has in place direct target areas, for economic contribution, associated with land restitution in conservation zones adjoin the National Park	The institution plays a social role of marine protected areas and the costs that they impose small scale agriculture and climate change, illegal fishing and community responses to it in the fishing communities	Environmental Policy Research Unit serves research and policy advice. Research areas include: township air pollution, the plastic bag levy in South Africa and Botswana
5	In general the institution has a vision of being a dynamic African university, recognised for its leadership in generating cutting-edge knowledge for a sustainable future	The institution mission is to offer a diverse range of quality educational opportunities that will make a critical and constructive contribution to regional, national and global sustainability	Engages in mutually beneficial partnerships locally, nationally and globally to enhance social, economic, and ecological sustainability

Discussion

The higher education sector is the second largest performer of R&D in South Africa and contributes the largest component of human resources devoted to research activities. The analysis of HERD in terms of socio-economic objectives (SEO) in the 2009/10 survey, indicates that the largest proportion of HERD was devoted to the advancement of knowledge (36.0%), followed by economic development (34.1%), society (23.1%) and the environment (6.8%). The Fourth Respondent is an active member of the Worldwide Universities Network, which comprises 19 research-intensive universities spanning six continents. Three out of the five respondents have a well-established incentive policy for research commercialisation. The incentives, financial and administrative, occur both at the level of the individual researchers involved in exploitation of research as well as at the level of the research groups involved.

8.6.1 Sustainable Development and Research Commercialisation Policies

<u>Does your institution have in place policy documents that apply specifically to research and sustainable development? If yes, what is the one main objective of each?</u>

Policy documents that apply to research and SD at the HEIs are outlined in Table 8.6.1-1. Sustainable development has been identified as a critical policy imperative at the five institutions. The HEIs have adapted their vision and mission statements to meet the needs and culture of the learning environment and to commit to a level of engagement with SD from the subsequent statements. In all the institutions, SD is implied in the CE policies, which deal directly with the communities. Three of the five institutions do not have separate policy documents pertaining to economic, social and environmental pillars. The second institution has a separate research and SD policies. The fourth institution is in the process of developing separate policy documents in the areas of economic, social and environmental pillars.

Table 8.6.1-1: Policy documents that apply to research and sustainable development at HEIs

HEIS	SUSTAINABLE DEVELOPMENT (SD) POLICY DOCUMENTS	HAS SD POLICY
1	A research policy is in place for conducting research, but no separate research commercialisation policy. Research Policy Development is in place, more policies were approved in 2012. One example is the Research Associate Policy which promotes capacity building in research. The institution does not have separate policy for SD; it is incorporated into existing policies. However the institution has developed a draft CE policy, with the main purpose being to regulate the processes of exchanging and transferring knowledge, expertise and experiences between the HEIs and community development initiatives. The policy identifies the following activities: • Research projects (such as contractual research) with and in communities; • Consultation services within a community context; • The initiation and management of community development projects by UL staff and students; and • Short courses and workshops for community members.	No
2	The Institution does have Research Policies, approved by Council in 2012 but not necessarily linking them with SD. The Institution's SD is implied in the CE policies which deal directly with the communities. There is no separate research commercialisation policy. Currently no director of IP, the IP is under research office, but dedicated office is in the process of being set up.	No
3	No- the new CE policy (2014) will contain elements of research, SD and research commercialisation this but this is yet to be finalised. However the institution has in place an institutional strategy for research, innovation and CE 2012-2014. The HEI strategy for research, innovation and CE is derived from the Institutional Plan, a three-year rolling plan with provision for longer-term planning.	No
4	Yes, The institution has put in place a policy framework for responsible resource use. Draft environmental sustainability policy is in place, which is yet to be approved. The intention is to be able to adopt approaches to energy saving that are contextualised within a principled policy for environmental sustainability. The research and IP policies cater for research commercialisation policy.	Yes
5	The institution SD policies are integrated into the 2020 documents (vision, mission, educational, philosophy and strategic priorities).	No

As shown in Figure 8.6.1-1, forty percent of the HEIs have not separated research and SD policies, while twenty percent are in the process of separating SD policies from research policy documents. Only twenty percent of the HEIs have separate research and SD policies in place.

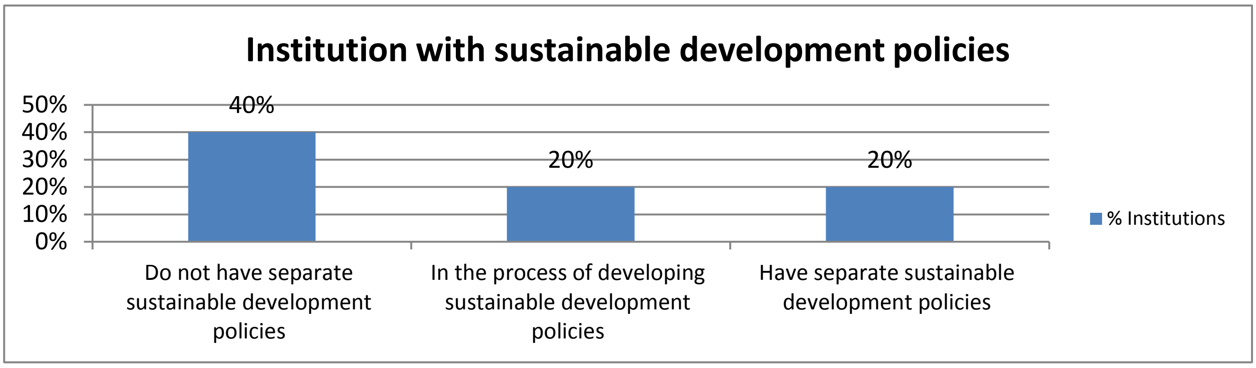


Figure 8.6.1-1: Institutions with sustainable development policies

Table 8.6.1-2 outlines the fourth respondent's principles of environmental policy. The draft environmental policy was developed in 2003, but has yet to be formally adopted. The policy includes sustainability in operations as well as in research, education and outreach. The draft policy resulted in the development of the Green Campus Action Plan of 2008, which is gradually being implemented.

Table 8.6.1-2: Fourth respondent's principles for the environmental policy

PRINCIPLES	MAIN INITIATIVES AND RESULTS
Principle 1: To demonstrate respect for nature and society, sustainability considerations should be an integral part of planning, construction, renovation, and operation of buildings on campus	• Efficient resource use in terms of -Energy efficiency Reduction of 10% against 2007 by 2014 and Reduction of potable water consumption • Waste management and emissions- reduction of waste to landfill through recycling; target of 70% recycling; develop reporting system • Research/IT facilities and sustainability- diversion of e-waste from landfill for reuse and recycling. Safe removal and disposal of hazardous chemical wastes • Users (inclusivity) - The on-going work of the Disability Service to provide advice, advocacy and support services to the disabled
Principle 2: Campus wide Master Planning and Target Setting	• Forest management study, planning process and consultation • Social Inclusion and protection- Services on campus: 30 food outlets 50 student sports clubs; 80 student organisations; Student Health Service; Kindergarten for 75 children.

Principle 3: Integration of Facilities, Research, and Education- To align the organisation's core mission with SD	• Social Integration- Education around 'green' issues; Participation in African and International Environmental Forums • Research & Education projects on Laboratory/IT facilities and sustainability- Maximise the use of the campus as a 'living laboratory' for student research projects • Commitments and resources for campus sustainability

Principle One entails sustainability performance of buildings on campus and embraces the principle of a low carbon economy and equal access (such as non-discrimination of the disabled). Principle Two includes comprehensive master planning with goals for impact management, for example, limiting use of land and other natural resources and protecting ecosystems. Principle Three entails ensuring long-term sustainable campus development, the built environment, operational systems, research, scholarship and education are linked as a "living laboratory" for sustainability.

Discussion

All the respondents indicated that they have strategic plans and policies that contain an explicit reference to research and SD. In general, the strategic plans of the HEIs use catchphrases such as 'innovation', 'engagement', 'sustainable development', 'community engagement', 'service delivery', 'responsiveness', 'equity', 'excellence' and 'integrity' 'excellence', 'stakeholders' 'partnerships', in referring to the mission and vision statements, which are rather vague and unclear in terms of how the terms are applied to macro-level dynamics and policy efforts in South Africa.

Majority of the HEIs also lack separate policies and mechanisms for research commercialisation and SD. The findings also indicate that the HEIs are yet to fully integrate SD into research. Integration based on all the three pillars is required for better use of scarce resources for development. Having in place separate SD policy documents does not imply separation from research activities. In essence, the traditional separation between research and SD issues is undesirable. From this perspective, the development and implementation of separate policies serves as models for evaluating SD efforts, for strategic convergence and as points of reference for strengthening the research chain from conceptualisation to execution, evaluation and commercialisation.

The findings indicate that the strategic choices made by the HEIs include: science-based innovation activities, especially technology transfer, engagement in the labour market, through lifelong learning in the working life, engagement in socio-ecological development for sustainability, engagement in regional development and engagement in wider societal debate. The HEIs strategic plan should be translated in conjunction with a complementary range of plans, such as individual colleges and campus, CE and equity plans, which may have different trajectories, which collectively respond to the position adopted and the challenges facing the HEIs.

8.6.2 Sustainable Development Challenges

What are the main challenges facing your institution with respect to the above policies?

The challenges pointed out by the respondents with respect to SD are outlined in Table 8.6.2-1. These challenges range from policy implementation to unavailability of adequate human resources and funding. The social-equity challenges facing South Africa's HEIs will require addressing significant weak points such as overall efficiency, SET enrolments, postgraduate enrolments and transforming institutional and academic cultures.

Table 8.6.2-1: Sustainable development challenges at respondent HEIs

HEIS	SUSTAINABLE DEVELOPMENT CHALLENGES
1	i) Difficulty of monitoring and implementing policies, as there is not enough manpower to monitor the policies. Monitoring tools that are easy to use and are effective are required.
2	i) The main challenge is the implementation thereof, due to the limited financial resources as well as lack of capacity in terms of human resources skills and knowledge. ii) Poor communication on the meaning and concept of SD.
3	i) Lack of basic skills with the grassroots community for example financial management, administration, planning and strategic management skills. ii) Lack of skills from academe to deal with these kinds of challenges due to the general and practical nature of some of the requirements. iii) Understanding of the purpose of SD. iv) Resistance to shifting away from basic research to more applied research has not been widely accepted among all academics. v) The multi- and trans-disciplinary nature of the development challenge is not supported by the existing funding models at HEI's. vi) Communication challenges.
4	1. The institution does not foresee any SD challenges as the concept is now a broadly supported concept and many of the opportunities available for research funding actually stipulate that the research should embody aspects of SD.
5	2. Sustainable development challenges relate to the funding capacity and policy issues.

Discussion

Based on the survey results, it appears that some of the HEIs have adapted their strategic policies and subsequent statements to demonstrate their level of engagement with SD. Furthermore, the findings also indicate a strong disconnect between research commercialisation units and SD (economic, social and environmental) priorities.

The results also indicate that the HEIs are not at all geared towards the concept of SD, which is visible in the form of the existing funding mechanisms for research. In contrast to fundamental or basic research (Mode 1 knowledge production), the NRF, for instance, prioritises experimental development, systematic work and knowledge produced in the context of application or evidence-based policy research (Mode 2 research) in the form of 'Competitive Industry Programmes', which are linked to specific governmental goals. In order to provide stable core funding for public research, a balance between competitive funding and institutional funding of HEIs should be maintained. This institutional funding should be complemented by rigorous performance evaluations in order to ensure efficiency and adequate returns on the investment in public research. Government funding and incentives emanating from various policies lack both clarity and stability, thus creating dilemmas in terms of (long-term) strategic planning at the HEIs.

The survey findings suggest that both the HEIs and the overall NSI situation are unbalanced. Achieving a balance amongst the HEIs core functions (teaching, research and community engagement) is an example of such a dilemma. The findings also indicate that the bulk of research efforts are centred on basic research (Mode 1) inquiries and restricted to the endeavours of postgraduate students (Master's and PhD levels). Firstly, most of postgraduate students leave the HEIs upon graduation and, therefore, do not directly contribute to (long-term) SD and research capacity-building. Secondly, the students' research activities, by and large, are unpublished outside the internal channels of the HEIs. However, some HEIs have since 2013 required that PhD students submit an article together with supervisors before mark is set out for exam.

8.7 SECTION 3: EFFECTIVENESS OF RESEARCH COMMERCIALISATION

The section evaluated issues with regard to research commercialisation, the barriers/challenges to be overcome, factors and the role of institutions IP rights office in research commercialisation. The aim was to evaluate the HEIs in terms of their readiness and effectiveness to manage research and innovation.

8.7.1 Commercialisation of Research

Has your institution played a role in commercialisation of research in the last five years?

Table 8.7.1-1 summarises the role played by HEIs in commercialisation of research during the last five years. The respondents recognised the role of HEIs in research commercialisation for SD. Two of the respondents indicated that their institutions had just started a dialogue about commercialisation issues. One of the HEIs has been involved in research commercialisation on a large scale, while two of the HEIs have also been involved in research commercialisation however on a small scale. A lack of qualified personnel and lack of funds was cited as the greatest obstacle encountered by the HEIs in commercialisation.

Table 8.7.1-1: Role played by the HEIs in commercialisation of research

HEIs	ROLE PLAYED BY THE HEIs IN COMMERCIALISATION OF RESEARCH	COMMERCIALISE
1	The respondent institution has just started a dialogue about commercialisation issues. The HEI recognises different categories of research in line with vision and mission, namely: pure, applied, innovation and community centred research.	No
2	The institution has made attempts to commercialise research only through research conferences as well as selling the findings/ideas to other institutions. This normally takes place in medicine and engineering faculties.	No
3	The HEI has been involved in research commercialisation. The institution focuses its research and innovation strategy to optimise resources and ensure maximum impact of interventions. The HEIs addresses the "innovation chasm" between research results and socio-economic outcomes. The HEI uses the formation of innovative small and medium sized spin-off companies as part of its commercialisation strategy. Since the merger in 2004, the total technology spin-offs increased from nine to 16 in 2010, of which 13 were still active at the time. At the end of 2010, the institution had four subsidiaries and associated companies. The HEI benchmarks include number of patents registered in South Africa and abroad, the number of new licence agreements, the income from royalties and product sales, and the number of new spin-off companies, subsidiaries and associated companies.	Yes
4	The HEI has been involved in research commercialisation. The HEI further indicates the use and formation of spin-out in research commercialisation, such as: (i) Tuluntulu (Pty) Ltd, which was formed to commercialise IP developed by a TIA-funded consortium led by the CSIR, to which the HEI had contributed IP; (ii) The PST Sensors (Pty) Ltd; (iii) The technology, Adaptive Real-Time Internet Streaming Technology (ARTIST) was recognised through an award from the NSTF-BHP Billiton for Outstanding Contribution to SETI and Innovation.	Yes
5	The HEI indicated with a "yes", with regard to research commercialisation. The HEI provided with the strategic document which highlights areas of research commercialisation.	Yes

The results of HEIs engagement in research commercialisation during the last five years are summarised in Figure 8.7.7-1. Forty percent of the HEIs have not been involved in research commercialisation, even though dialogues are taking place, while sixty percent have been involved in research commercialisation.

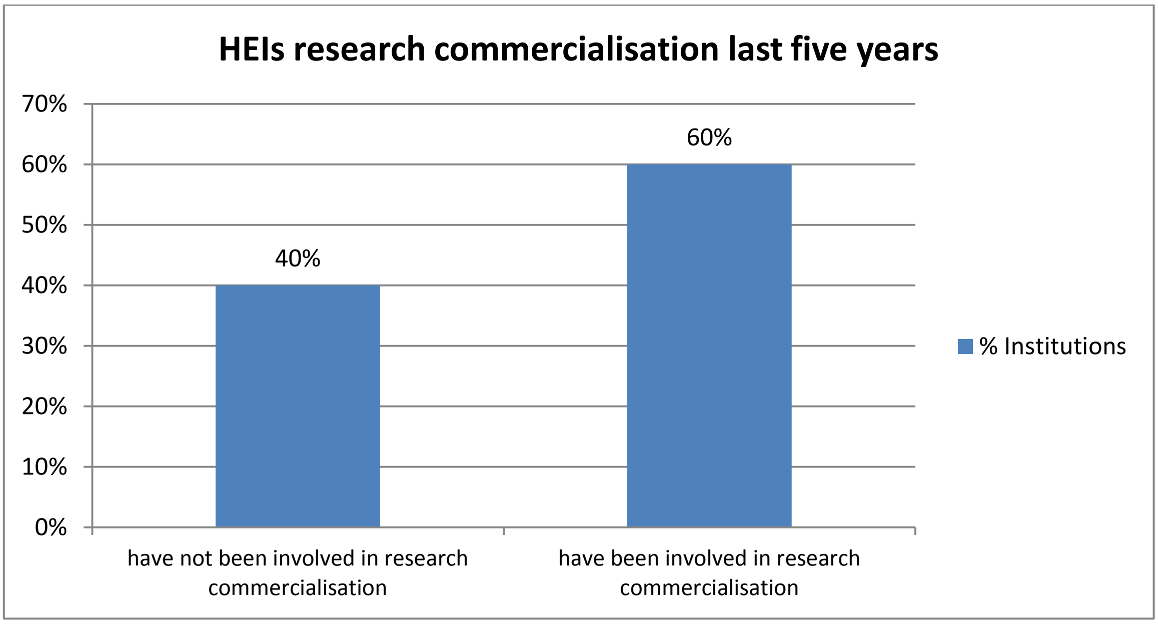


Figure 8.7.1-1: HEIs in commercialisation of research

All the respondents recognised the importance of supporting a mix of CE, SD activities, management of IP and the creation of spin-offs to generate important spill-overs from research commercialisation. Four of the respondent HEIs combine the aforementioned activities within the research office or technology transfer office (TTO) structure.

Table 8.7.1-2 outlines the first institution's innovation, responsiveness and research commercialisation activities during the last five years. Further assessment of the Respondent One institution indicates a research output amounting to 219.23 units for books, conference proceedings and journals for 2012 publications. This is an increase of 71.68 (48.6%) from the 147.55 units awarded for 2011 publications.

Table 8.7.1-2: Institution one innovation, responsiveness and research commercialisation

INSTITUTION 1 INNOVATION, RESPONSIVENESS AND RESEARCH COMMERCIALISATION
• Promoting and strengthening research and innovation place during 2012 and 2013, which include: o Establishing a collaborate programme with Turfloop satellites campus like: EDUPARK, Polokwane Hospital and Dalmada Health Research Centre. o Finalised the provisional research patent application in March 2012. o Dialogue on a Community Business/Research on Essential Oils and Moringa for Biofuels. • During 2012 the respondent institution was involved in strengthening research and innovation with external partners , such as: o Participated in NRF and Academy of Finland Academy Workshop on “Children and Youth”. o Anglo Platinum / Limpopo Provincial Government - Fuel Cell Strategy Workshop. o Participated in various workshops, which includes: Productivity SA and MISTRA workshop, Higher Education South Africa, National Workshop on Full Costing of Research Projects. • The respondent institution has developed policies enforcing the recovery of indirect cost on research projects and b-Branding and Marketing the Research Office and its Services has been taking place. **According to the institution, suggestions for Improvement of the respondent institution Research Office and Its Services include:** • The use of appointments and consultation schedule. • Planning and schedule for Research staff. • Use of the evaluation form to improve services. • Establishment of the Postgraduate Centre (PGC) within the Research Development and administration can also assist to address the following objectives to: o Supporting the Social Science Research Methodology. o Addressing the needs of quality supervision and mentorship among academic staff. o Collaborative programme with the NRF to establish a writing workshop for Thuthuka grant-holders. o Holding science workshops for research for the Health Sciences, Engineering and Science faculties. o Holding a Research Day and postgraduate symposium which will showcase some of the high quality postgraduate student research conducted. o Coordinating, extending and enhancing the postgraduate support systems. o Assisting the institution in attracting, training and delivering quality postgraduate students; and o Increasing the number of postgraduate students (Masters and Doctoral).

Table 8.7.1-3 highlights the third institution’s innovation, responsiveness and research commercialisation activities during the last five years, which shows involvement in commercialisation activities ranging from cultural dynamics, socio-economic, health and educational during 2013. The institution was granted the most THRIP income of all universities in South Africa, an indication of the innovative and relevant research done in close association with the private sector. As at 2013, the institution had 117 researchers with NRF ratings.

Table 8.7.1-3: Institution three innovations, responsiveness and research commercialisation

INSTITUTION 3 INNOVATION, RESPONSIVENESS AND RESEARCH COMMERCIALISATION
• The engineering students and staff are collaborating with companies on a number of high-tech projects, developing new products and solving difficult problems. • The HEI named technologically innovative HEIs in South Africa for 2008 by the DST. • The Faculty of Engineering boasts a world-class fabrication laboratory (Fablab). • The 18-m wingspan JS1-Revelation glider, designed by a lecturer of the School for Mechanical Engineering, was awarded an Aircraft Type Certification by the SA Civil Aviation Authority (SACAA) in 2010. Brand Design Council of South Africa named Institution One out of five top Graphic Design educational institutions for 2010. • CTexT®: The Centre for Text Technology (CTexT) is involved in R&D in the field of Human Language Technology (HLT). Some of CTexT's outputs include spelling checkers for Microsoft Office, open source translation tools and language learning software. • The HEI has two centres of excellence. These are the Centre of Excellence for Nutrition (only centre of excellence for nutrition in Africa, aims to improve the nutritional status of communities in Africa) and the Centre for Space Research (undertakes competitive research). • Unit for Drug R&D has developed and improved a unique drug delivery technology, Pheroid®. • International player in HIV/Aids treatment won a $7 billion tender to contribute to the United States' President's Emergency Plan for Aids Relief (PEPFAR). Other potential niche areas: • **NICHE AREAS:** o The Cultural Dynamics of Water (CuDyWat), Socio-economic Impact of Tourism o Educational Technology for Effective Teaching, Learning and Facilitation o Physical Activity, Sport and Recreation(PhASRec) o Medicine Usage in South Africa (MUSA)/Population and Health • **FOCUS AREAS**: o Chemical Resource Beneficiation/Teaching-learning Organisations/Social Transformation o Understanding and Processing Language in Complex Settings (UPSET) o Hypertension in Africa Research Team (HART) o Enabling Optimal Expression of Individual, Social and Institutional Potential (Optentia) o Food Security and Safety in the Province/Musical Arts/Resources and Applications • **UNITS**: o Unit for Energy Systems/Unit for Reformed Theology and the Development of the South African Society/Unit for Business Mathematics and Informatics/Unit for Languages and Literature in the South African Context/Unit for Environmental Sciences

	2007	2008	2009	2010
Total research output*	1 061	1 083	1 190	1 318
NRF-rated researchers		95	103	117

*

*Includes research master's, PhDs times three and publications (including an estimation of books, conference proceedings and articles).

Institution Four's innovation, responsiveness and research commercialisation activities during the last five years are outlined in Table 8.7.1-4. The results shows that the institution has been involved in research commercialisation activities ranging from water recycling, technology and health, which have direct and positive implications for the private sector. Additionally, the respondent asserted that the commercialisation initiatives are making significant contributions to addressing societal problems and influencing growth and development, both in South Africa and on the continent. The institution achieved the second-highest national publication count in 2012, a total of 1314.40 units for research publications produced in 2011. The institution also hosts 33 SARChIs as well as two national Centres of Excellence, namely: the Birds as Keys to Biodiversity Conservation and co-hosts a node of the Centre of Excellence for Biomedical TB Research and the Hydrogen Catalysis Competence Centre with Mintek.

Table 8.7.1-4: Institution Four's innovation, responsiveness and research commercialisation

INSTITUTION 4 INNOVATION, RESPONSIVENESS AND RESEARCH COMMERCIALISATION
Some of these include: • Recycling of water, which have direct, and positive, implications for the private sector. However, little of the research output has provided the private sector with technologies or products they could use themselves. Many Environmental Impact Assessments (EIAs) require an economic input. Depending on the outcome, this might not favour the business commissioning the study, but would nonetheless be relevant to them. Another example is the issue of mine closure certificates: the private sector would undoubtedly like to see these provided at lower cost, but funds should be set-aside at the beginning of mining operations in order to cover the costs of final closure. • Contribution of research in astronomy to the national flagship projects of the Karoo Array Telescope (MeerKAT) and the Square Kilometre Array (SKA), one of the largest scientific experiments. • Research that has direct relevance to national policies aimed at poverty reduction, promotion of growth, and the reduction of inequality. • World-leading research undertaken by the Institute of Infectious Disease and Molecular Medicine in partnership with Malaria Venture (MMV). • Research on the development of new forms of digital technology to address the developmental problems within society, problems that do not exist in developed economies, where most of the world's technology is created. • Innovative research into water treatment, which impacts a broad range of sectors, ranging from industrial and commercial applications, to impacting the lives of all South Africans.

Highlights in respect of innovation, responsiveness and research commercialisation at the Institution Five are shown in Table 8.7.1-5. The findings indicate a significant expansion in the number of strategic partnerships and links with industries, sector education and training authorities, local and provincial governments, schools, and development agencies.

Table 8.7.1-5: Fifth institution innovation, responsiveness and research commercialisation

INSTITUTION 5 INNOVATION, RESPONSIVENESS AND RESEARCH COMMERCIALISATION
• The arrival of the only high resolution transmission electron microscope in Africa funded by the NRF. • The establishment of a new Chemical Fuels Technology Centre at InnoVenton, in collaboration with major industrial players, including PetroSA, CSIR and Sasol (which was awarded the national innovation competition in 2007). • The HEI in partnership with Afrepell Manufacturing Pty Ltd will be commercialising a range of insect repellent products developed by InnoVenton. • The invention of an environmentally-friendly additive likely to revolutionise the tyre industry worldwide. • The International Chair in Automotive Engineering has reinforced strong linkages between the HEI and the automotive industry and has provided students with numerous exciting opportunities including formula student racing where students from various faculties are required to work together to design and develop a small racing vehicle that can compete against other tertiary institutions from around the world. • The Automotive Components Technology Station (ACTS) is currently involved in a multi-million rand research project in support of the local nuclear industry, which could result in reduced costs and increased reliability through research aimed at developing specialised platforms for using friction stir welding as a possible weld repair procedure. • The Centre for Energy Research is researching some promising alternative "green" energy solutions, including solar and fuel cells, aimed at commercialising its application for the South African economy. • Pioneering and influential work done by the institution's scientists in areas such as biodiversity, restoration ecology, information and communications technologies, language and media studies, diabetes, and bio kinetics. • Recent breakthrough findings by the HEI researchers in diabetes treatment using an extract of an indigenous plant, Sutherlandia frutescens, may be the recipe for success in the lives of thousands of diabetics. • Appointment of some of the leading researchers and professional staff members onto international, national and regional advisory and policy-making councils that influence public policy. • Responsible approaches to widening access through a centralised, developmentally-focused approach to admission, placement and support of students and providing and development services to assist students to succeed. Having a range of qualification types assists in giving access to a wider range of students and also to allowing students to further their studies by articulating from one qualification to another. • A wide range of initiatives to improve the quality of S&T and Mathematics education in secondary schools through programmes targeting both learners and teachers. • Involved in licensing and/or spin-off projects, in order to hire (retain) young local engineers by creating a spin-off company to undertake engineering innovations, rather than licensing the technology to an existing manufacturing company.

Discussion

Even though 60% of the HEI undertake research commercialisation, the findings indicate that the overall level of research commercialisation at the HEIs is low. The Third Respondent noted that the strength of triple helix linkages, that is the HEIs and the formal private sector, is typically gauged in terms of how closely the institutions work together to commercialise research. The findings indicate that the structures dedicated to commercialisation by 20% of HEIs are operating on minimal budgets, with perhaps low expertise related to intellectual property rights management.

However, in South Africa, like other African countries, the informal sector comprises a large part of the productive sector, followed by agriculture, small high-technology and mineral extraction. Therefore, the role of HEIs in promoting productivity gains throughout the larger South African private sector should include agriculture and the informal economy. Instituting a shift from the current NRF rating system towards one that makes provision for the rating of highly private groups, rather than individuals, would greatly facilitate in multiplying the distributive effects of resource provision. Rather than making periodic general competitive calls for a particular kind of resource, various forms of research support should be customised and coordinated to meet research needs.

8.7.2 The Role of Higher Educational Institutions in Assisting the Private Sector

What roles could be foreseen for HEIs research in assisting the private sector?

The suggested roles of HEIs research in assisting the private sector is outlined in Table 8.7.2-1. In general, the respondents indicated that HEIs research should be aimed at solving problems in the private sector. The respondents also noted that both the HEIs and the private sector should play an active and collaborative role in research commercialisation.

Table 8.7.2-1: Potential role for HEIs research in assisting the private sector

HEIS	THE FORESEEN ROLE FOR HEIS RESEARCH IN ASSISTING THE PRIVATE SECTOR
1	- The private sector could plan and commission research from HEIs; the relationship will result in more solution-driven research. - Research should be specifically aimed at solving problems in the private sector. - Contract management, Cooperation management.
2	- HEIs should undertake research activities that are informed by the private sector since the graduates will work with the industry. - There should be collaboration between the HEIs, public and private sectors concerning research for purposes of mutual benefit. - The HEIs should take the lead in enhancing the development of the communities where they are established, they should be community based.
3	- Researchers may assist by doing consultancy work.

	- The HEI has 36 THRIP projects creating partnerships with industry. - Technology Transfer from the HEI to private sector. - Corporate Social Investment projects initiated and managed by the participating institution. - Knowledge creation and sharing through teach and learning and research ending in publications.
4	- Research has implications for the private sector, though it may not assist it directly. - Managing cooperatives with local business entrepreneurs. - Contract negotiation. - Developing new technologies for industry. - Planning for collaboration, cooperation. - Networking and seeking out external partners.
5	HEIs should: - Undertake research for private sector. - Develop new technologies for industry. - Commercialise research and create new businesses. - Negotiate contract, Manage partnership.

The suggested roles of HEIs research in assisting the private sector is further illustrated in Figure 8.7.2-1. In the NSI schema, the private sector, HEIs and PRIs synergise towards innovation. All the respondents agreed that the HEIs should facilitate collaboration activities with the private sector. The Fifth Institution stated that "HEIs are probably not designed in a manner that predisposes them to easily play that sort of instrumental role".

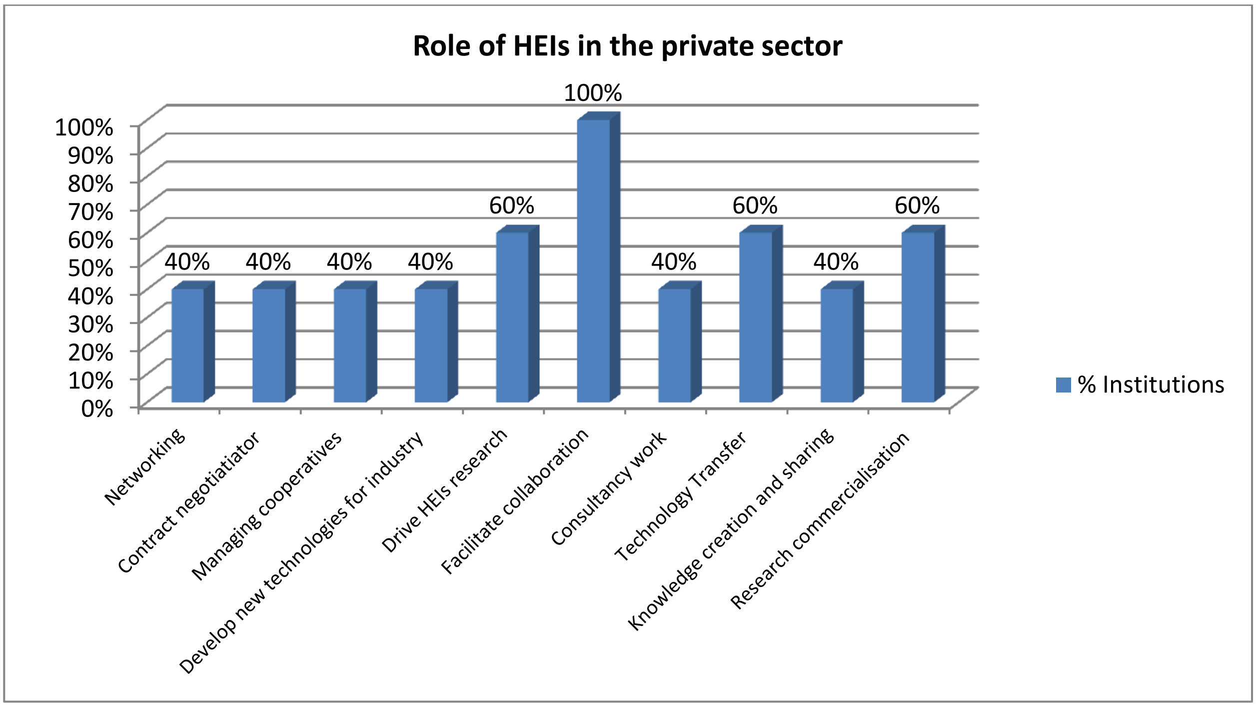


Figure 8.7.2-1: Role of HEIs in the private sector

Discussion

As indicated in Table 8.7.2-1 and Figure 8.7.2-1 the potential, unexploited HEIs-productive sector partnerships represent an important alternative for driving research and SD in South Africa. The inclusion of private sector linkages within the HEIs strategic plans emerged as an important factor for research commercialisation. Similarly, the strengthening and introspective development of concrete action plans within HEIs for effective deployment is required for research commercialisation and SD.

8.7.3 Barriers Facing Higher Educational Institutions in Assisting Private Sector

What current barriers need to be overcome in the HEIs research assisting the private sector?

Despite on-going efforts to increase collaboration within the NSI actors, as shown in Table 8.7.3-1 there are still some substantial barriers that should be addressed. The HEIs and PRIs remain the primary sources of skills required by the private sector's competences in the use of advanced scientific equipment and business management. However, globally including South Africa, the private sector does not rank HEIs and PRIs as important sources of innovation. This reflects a lack of NSI linkages between the two actors, in the light of the last 2010 R&D survey, which indicates a decline in the perceived importance of HEIs and PRIs innovations by the private sector. Nevertheless, the HEIs are essentially in the business of teaching (producing highly required skills) and research and not innovation per se, while the PRIs perform essential services and conduct applied research. Notably, however, the private sector is a major funder of research through THRIP and has high regard for the HEIs, thus the inclusion of South Africa's HEIs in international league tables.

Table 8.7.3-1: Challenges to be addressed in the HEIs research

HEIs	BARRIERS THAT NEED TO BE ADDRESSED IN ASSISTING THE PRIVATE SECTOR
1	• Not much collaboration currently • Finances are always a problem • There is need of a common understanding or a platform on which to interact • Researchers working in silos • Poor communication • Lack of strategic leadership • Lack of awareness and information • Lack of research capacity and entrepreneurial • Absence of national policies
2	• Lack of financial resources • Leadership issues • Information skills are also limited • Lack of cooperation between the parties involved

	• The HEIs are not aware of the needs of the industry and/or private sector • Lack of entrepreneurial skills/knowledge among academic staff
3	• Research must be more problems-based addressing the needs of the community/industry. • Research commercialisation must be part of the core function of the institution. • Expectations from the community must be realistic and outcomes must be well defined and negotiated upfront
4	• Silo mentality • The lack of critical mass of researchers • Lack of collaboration • Communication challenges • Inadequate research infrastructure such as laboratories
5	• Time constraints of academics to undertake research and engage in research commercialisation • Fragmentation issues, ad hoc, opportunistic • Lack of interdisciplinary mind-set • Funding by private sector limited, as most of the private sector do not understand costs associated with research • Lack of triple-helix communication, established networks with the private sector • Funding of commercialisation offices – not seen as core business by universities so funding a challenge • Lack of commercialising experience • Time frames for commercialisation are long – this must be understood by HEIs • Lack of staff to develop university/industry, collaboration relationships • Lack of staff with research commercialisation expertise • Inadequate research infrastructure

As shown in Figure 8.7.3-1 the most cited challenges that need to be addressed in the HEIs research in assisting the private sector were:

- Lack of funding (100%).
- Lack of capacity (human and machinery, infrastructure) (100%).
- Lack of common purpose (80%).

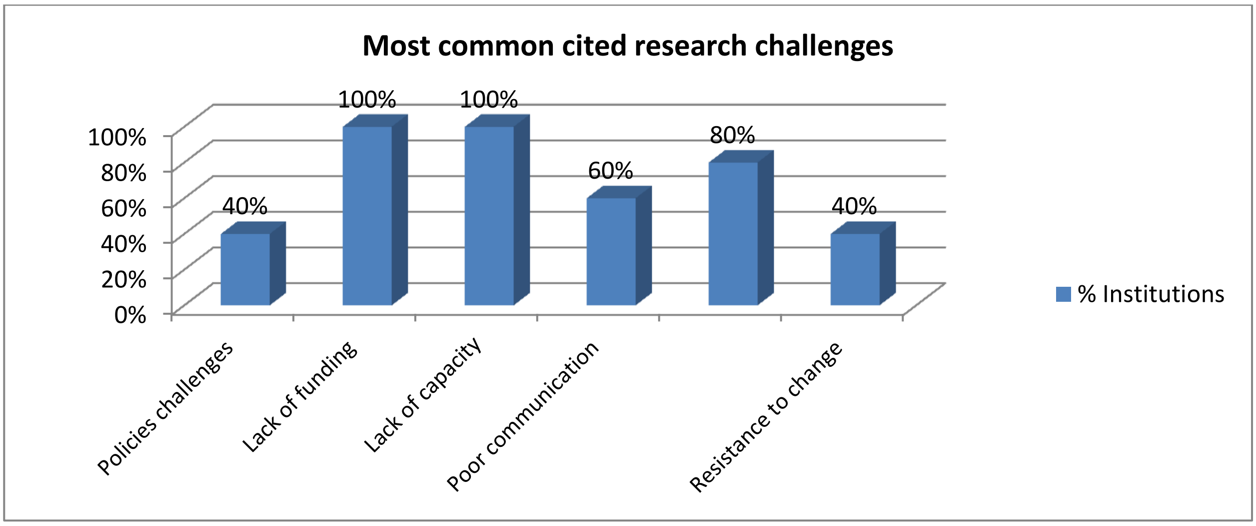


Figure 8.7.3-1: Most common cited sustainable development challenges

Discussion

Table 8.7.3-1 and Figure 8.7.3-1 indicate that research challenges facing HEIs can be classified into two:

- Lack of critical mass of researchers, with the most private researchers operating independently and in isolation, with no research team; and
- Difficulties in instituting an interdisciplinary mind-set due to traditional 'silo mentality'.

In addition, the HEIs also have struggled to recruit emerging researchers due to uncompetitive salaries within the HEIs. Commercialisation of research has not been undertaken in some of the HEIs owing to the small base of funding, equipment and human resources and is unlikely to increase without a substantial injection. According to the respondents, the bottlenecks that represent considerable constraints to commercialise research include:

- The lack of infrastructure to support high-quality teaching.
- Undertaking research and CE in a multi-campus/colleges context.
- Diversifying the staff equity profile.
- Establishing a transformative institutional culture that maximises the full potential of the students and staff.

Moreover, employment social-equity plans have not been achieved because of:

- Lack of competitive remuneration in the HEIs relative to the private sector.
- Limited pool of qualified and experienced academics, especially in scarce skills areas.

In an open-ended question, the respondents were asked to list the barriers/challenges that should be addressed in the HEIs research assisting the private sector. The findings indicate that strengthening the NSI linkages between the HEIs and the productive sector is constrained by the lack of research commercialisation skills and low numbers of qualified staff, including doctorate degree holders. The respondents also listed brain drain, ageing faculty and poor staff remuneration and low retention as constraints in research productivity. Inadequate investment and infrastructure in research and failing to incentivise research commercialisation also hampered the HEIs research assisting the private sector, so was low student enrolment and poor performance in S&T disciplines.

The respondents also listed lecturing responsibilities, rather than research-focused mandates, and poor, opportunistic *ad hoc* interactions between HEIs' and private sector as constraining the HEIs' research assisting the private sector. The absence of trilateral dialogue among the science councils, HEIs and provincial governments was also listed as a constraint. The aforementioned limitations should, however, not deter the NSI actors from strengthening their relationship with the HEIs, but should be taken into account in construction of NSI policies, strategies and interventions for the HEIs.

8.7.4 Factors for Successful Research Commercialisation

From your research perspective, identify some factors that can lead to successful research commercialisation in your institution

A list of factors that can lead to successful research commercialisation, according to the respondents, is presented in Table 8.7.4-1. In general, the finding indicates the need to increase research capacity in terms of funds and human resources. Proactive planning by the HEIs was also cited as an important factor that can lead to successful research commercialisation.

Table 8.7.4-1: Factors that can lead to successful research commercialisation

HEIs	FACTORS THAT CAN LEAD TO SUCCESSFUL RESEARCH COMMERCIALISATION IN THE HEIs
1	• Dedicated staff must be allocated • Strategic planning should include commercialisation • The research niche areas should be directed towards commercialisation
2	• Cooperation • Increase in funding by the Government that is the NRF • Capacitation of the people/skill development • Develop and support emerging researchers
3	• Formation of research clusters • Industry partnerships at outset of research • Seed funding • At present the following factors and strategic intents will play a critical role in the success of the HEI in attaining its research goals: diversity in student profile, staff profile, market attractiveness, research investment, application of competitive edge, internationalisation of research and research output
4	• Train new researchers • Planning • Channelling more funding into research
5	• More skilled staff needed – there is a lack of skills in the South Africa • Need good pipeline of projects so must get involved in early stages to ensure IP considered in all research projects • Seed/prototype funding to drive projects to next stage • Increase research capacity • Planning for collaborations and partnerships

Common factors considered for research commercialisation, as shown in Figure 8.7-4-1, were: (i) increase in human resources (80%), (ii) planning (40%) and (iii) seed funding (40%).

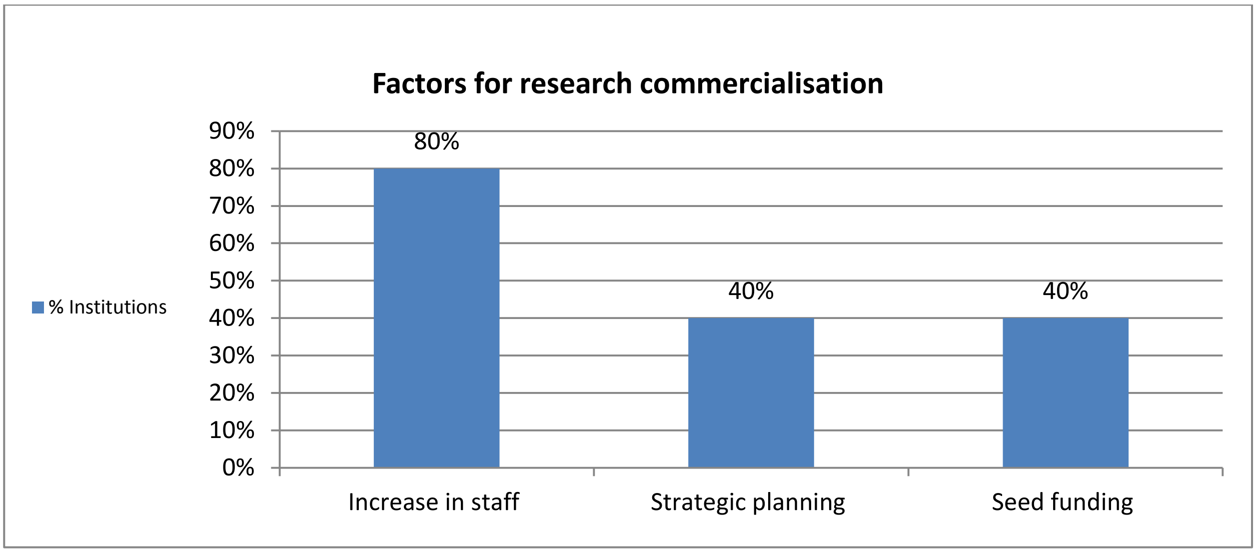


Figure 8.7.4-1; Factors for research commercialisation

Areas of collaboration between the HEIs and the private sector were most active in: agribusiness, environmental management, ICTs and banking and engineering. The results are summarised in Figure 8.7-4-2, which presents the sectors that respondents have been engaged during the last five years.

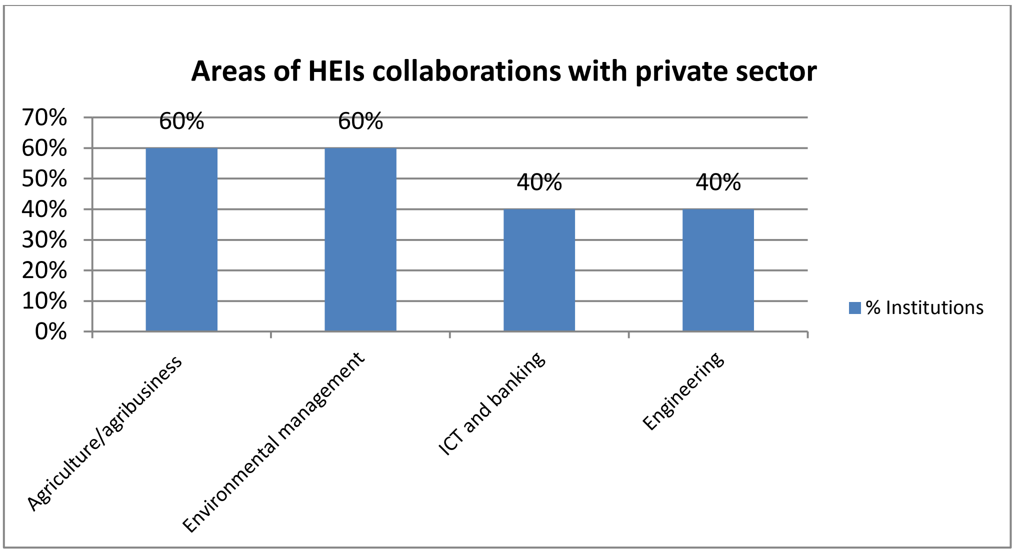


Figure 8.7.4-2: Reported HEIs collaborations with private sector

<u>Discussion</u>

Factors that can lead to successful research commercialisation indicate that the HEIs research capacities, skills and expertise should be prioritised even before consideration for funding. Research commercialisation also entails a certain level of risk, which may or may not generate profits, where economic benefits often accrue disproportionately in favour of the private sector. Therefore, HEIs' partnerships with the private sector within the NSI should not be assessed only through the potential financial lens, but also in terms of the broader contributions of partnership to SD in South Africa.

8.7.5 Intellectual Property Rights Office at Higher Educational Institutions

<u>What role has your institution's intellectual property (IP) rights office played in research?</u>

Table 8.7.5-1 outlines the various roles played by the IP rights offices suggested by the respondents. While the majority of respondents reported having a strategic plan that contains an explicit reference to building linkages with the private sector, many lack the backing policies and mechanisms for regulating interactions with the private sector.

Table 8.7.5-1: Role played by the institution's intellectual property rights office

HEIs	ROLE PLAYED BY THE INSTITUTION'S INTELLECTUAL PROPERTY RIGHTS OFFICE	HAS IP OFFICE
1	• Respondent institution does not have an IP rights office. All IP issues are handled by the Research Director who acts on behalf of researchers especially with outside agencies. Have no official policy regarding sharing and ownership of IP	- No
2	• The IP Policy unit have played very limited role, because it lacks capacity.	- No
3	• The Technology Transfer and Innovation Support Office (TTISO) provides a legal and compliance function supplemented by assisting in the innovation process by managing the contracting process and assisting with the negotiations. • Patents and income from product sales generate around R3 million a year. The institution holds nine patents in the USA. • Institutional Plan provides strategic guidelines for the implementation of expertise in the form of: o Assignment of IP rights. o Indemnity; and moral rights waiver in the case of copyright. • Which all discoveries must be reported to the TTIS OFFICE within 90 days of discovery and the TTIS OFFICE must report all disclosures biannually to NIPMO.	- Yes
4	• Research Contracts & IP Services (RCIPS) is responsible for maintaining and implementing IP Policy. The IP group at RCIPS provides a number of functions that support the protection of IP arising from institution's research endeavours, as well as its commercialisation.	- Yes
5	• The Innovation Support and Technology Transfer Office are responsible for managing projects, negotiate contracts, identify IP, protect and commercialising. • The Research office is responsible for all external research-related grants and contracts and plays a major role in the research projects even before they lead to commercialisation – value chain approach.	- Yes

The findings (Figure 8.7.5-1) indicate that 40% of the respondents do not have an IP office in place, while the rest (60%) either had an IP office in place or the research office played the IP role.

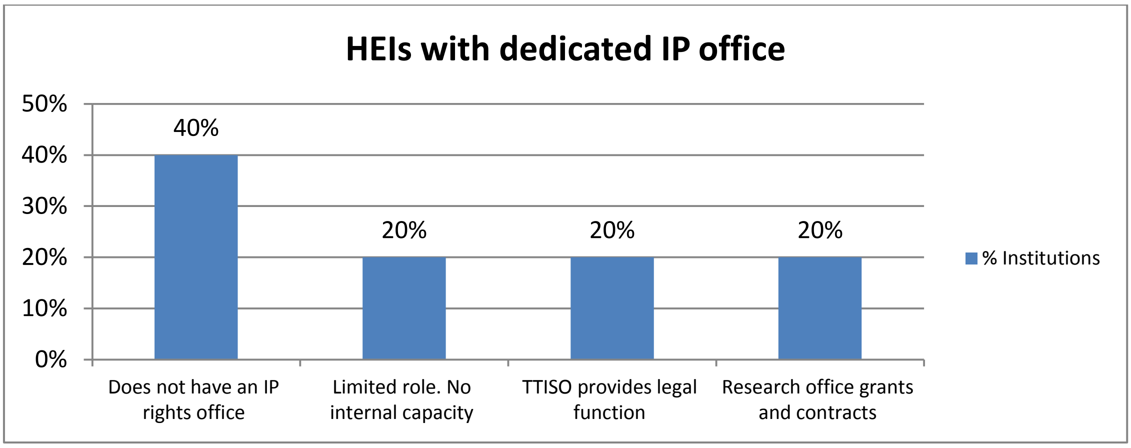


Figure 8.7.5-1: Has a dedicated IP office

Majority of the respondents pointed out that the process of creating or strengthening designated positions and/or offices for fostering HEIs-private sector linkages is in place. At present, the majority of such units are located in the Office of the Deputy VCs Research (or equivalent). These offices primarily focus on student enterprise activities and networking (100%); contract negotiation (60%); consultancy (60%); collaborative research (60%) and; licencing and spin-off (60%), as illustrated in Figure 8.7.5-2.

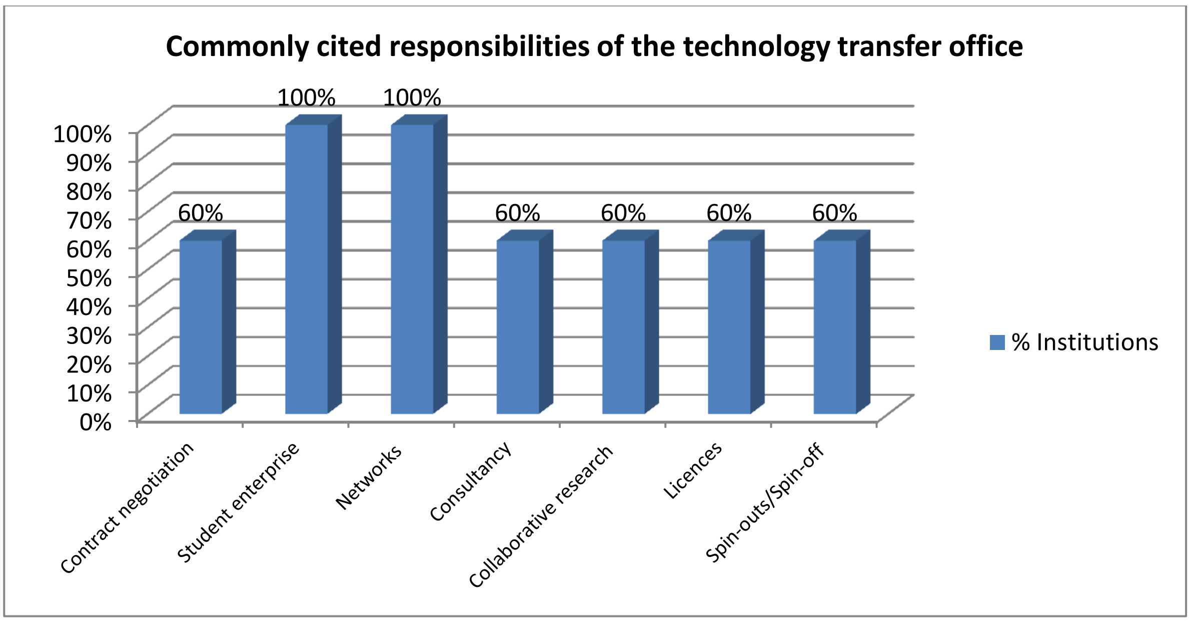


Figure 8.7.5-2: Commonly cited responsibilities of the technology transfer office

The Institution Three provided an overview of IP management activities outlined in Table 8.7.5-2. In general, between 2009 and 2013 several commercialisation activities were conducted at the institutions, which are yet to be registered or patented by the IP office.

Table 8.7.5-2: Commercialisation activities conducted at Institution Three

COMMERCIALISATION ACTIVITIES CONDUCTED AT RESPONDENT INSTITUTION THREE
Between 2009 and 2013 several commercialisation activities were conducted at Institution Three, which are yet to be registered or patented: - The ignition system (with commercial partner Ambixtra) is in a challenging phase – the second round financing for R15m and international proof of concept phase based on automotive system engineering standards consumed most of the time in the TT office. Two international accredited verification agencies tested the prototypes and indicated that the electronics of the HEI system is most advanced. These agencies are willing to introduce the technology to vehicle and ignition system manufacturers. - The SPIN series of six patents were supported. - A new internal venture (IV) has been set up at Biochemistry to manufacture and sell Co-enzyme - Another one for the manufacturing and sales of an anti-halitosis tablet is planned in the Faculty of Health Sciences. - Six other patents are actively being commercialised but are still in early stages. - The rest of the patents are on hold owing to a lack of resources. - Eight patents are being investigated for termination owing to either technical aging or a lack of funding for patenting. - The Director of the Office is involved in the governance of spin-off companies: Afriforte (Pty) Ltd (chair) and CFAM Technologies (Pty) Ltd.as well in the MyLab internal corporate venture. - The Director of the Office chairs the DTI's Centre of Excellence in Advanced Manufacturing. **New business development** - The TTIS introduced the National Tooling Initiative Programme to the engineering faculty. The HEIs now earns money through participating while extending its brand and network into the advanced manufacturing industry. - Discussions are underway to align with a UK-based group of venture capitalists to assist universities with the internationalisation of their technologies. Intellectual Property Management Patent applications The following patent applications were filed: • Six disclosures and two requests from non- HEIs inventors. • Four provisional applications, two PCT applications. • Four Patents have been referred to NIPMO for approval of their termination. • Continued processing of about 300 registrations world-wide. • NIPMO subsidy application completed and filed 30 October 2013 together with NIPMO bi-annual reports. • Hoping to receive 50% of total expenditure of about R4.8 million for the claim period.

Discussion

The findings indicate that South African HEIs internal IP policies are by no means uniform across the HEIs. In addition, the HEIs have different structures in place for managing IP. Some have set up dedicated offices, some have established associated companies (fully or partially HEIs-owned) and others utilise outside consultants and others have not taken any steps for managing IP. According to section 6(1) of the HEIs Act of 2008, HEIs are required to establish a technology transfer (TT) function at and 7(2) (a) which says that an IP policy is required. Furthermore, three respondents have established TTOs within the framework of the HEI administrative structure to serve the IP and patenting function, whilst TT responsibilities fall under the research office in two of them. Three of the respondents have made considerable investment in setting up infrastructure and supporting training, patenting and marketing costs.

The two main responsibilities of TTO highlighted by the respondents are student enterprise and networks management. HEIs have a legal obligation to exploit discoveries through the TTO and in partnership with the inventor(s) for the benefit of the HEI, its students and staff. The ownership of all copyright of employees of the HEIs in respect of works created vests in the HEIs in terms of section 21(1) (d) of the Copyright Act (98 of 1978). Contract workers are assigned to the HEIs copyright all works that may originate during the execution of contractual obligations. The creation of such offices is part of the South African government's strategy to promote knowledge transfer and research commercialisation. The findings further indicate that TTOs operate next to other intermediaries such as technology and innovation consultants for SMEs, technology and science parks, incubators, information provision systems and contact platforms. Nevertheless, there is no clear evidence of the effectiveness of these intermediaries and their primary role in research commercialisation at the HEIs. According to the respondents, the TTO offices lack an adequate scale and expertise related to IP rights management and resources to be efficient. The analysis has shown a strong disconnect between IP units and SD (economic, social and environmental) priorities in South Africa.

8.7.6 Suggestions to Improve Research Commercialisation

From your institutional perspective, what kind of policies should be pursued to improve the *research and research commercialisation of South African HEIs?*

Table 8.7.6-1 outlines of the suggested policies that could be pursued to improve research and research commercialisation in South African HEIs. Developing new policies and strengthening existing ones was cited as highly desirable for the improvement of research and research commercialisation.

Table 8.7.6-1: Suggestions to improve research commercialisation

HEIs	POLICIES THAT SHOULD BE PURSUED TO IMPROVE RESEARCH COMMERCIALISATION
1	• Must have an updated IP policy • Qualified personnel to handle IP matters • Commercialisation policy • Increased policy awareness
2	• Policies to strengthen research • Community engagement policies • Improve collaborative agreements with the private sector
3	• Conducting intensive research capacity building for researchers • Policy development
4	• Mass education • Civic awareness • Develop and improve relevant policy
5	• Policies for supporting organisations like Southern African Research and Innovation Management Association (SARIMA) that are building capacity in this space • Policy capacity

Discussion

The findings indicate that without guaranteed assistance from the government, HEIs are unable to meet the upfront costs of research commercialisation. Therefore, policy interventions such as increased funding, should seek to improve the production of experimental and strategic research at the HEIs. An emerging cross-cutting theme from this section appears to point to the importance of leadership both at the national policy and institutional levels. Furthermore, policies dealing with IP management should be focused on how the NRDS can best assist in strengthening research and commercialisation. In deepening HEIs engagement with the private sector, IP policies for mitigating research commercialisation related conflicts are critical.

The findings also indicated the need for deepening policy learning. A broader approach is required for designing evidence-based policy mixes and portfolios and enacting policy incentives for research commercialisation and its management. With a view to expanding policy options, the government should also consider developing national and regional policies and programmes regarding SD, such as public research grants to HEIs and government support in setting up of research cluster centres and research-based industrial parks that foster linkages between HEIs and the private sector. In addition, relevant policies to enhance the private sector relationships with other NSI actors will have to be part of an overall government strategy for creating the demand for public research. On the one hand, reliance on HEIs internal policy regulation might be arbitrary and inconsistent across institutions. On the other hand, policies must be sought to cultivate and nurture NSI actors' relationship without compromising the integrity and freedom of the HEIs.

However, prescriptive top-down policies to regulate the HEI-private sector relationship will be difficult to enforce and can interfere with research productivity as well as alienate private sector funders.

8.8 SECTION 4: NATIONAL SYSTEM OF INNOVATION ACTORS

This section examines the nature of the relationship between the HEIs and other NSI actors, the main weaknesses in that relationship and offers suggestions for strengthening the NSI relationships.

8.8.1 Proposed Nature of the Relationship among NSI Actors

<u>From your institutional perspective what should be the nature of the relationship between HEIs and business and government?</u>

The proposed nature of the relationship between HEIs, private sector and government, according to each of the respondents, is outlined in Table 8.8.1-1. In general, the research findings indicate a lack of inter-sector level dialogue between various NSI actors. The respondents proposed that the nature and relationship between these major NSI actors should be strengthened, for example, through establishment of policies, collaborations, cooperation and dedicated resources.

Table 8.8.1-1: Proposed nature of the relationship among HEIs and business and government

HEIs	PROPOSED NATURE OF RELATIONSHIP BETWEEN HEIs AND BUSINESS AND GOVERNMENT
1	• There should be collaborative research agreements between these partners. • All should work together so that research is not duplicated but rather directed. • Look at common national goals of research in order to make a national/global impact.
2	• Establish policies, collaborations, cooperation, dedicated resources between parties involved.
3	• The nature of the relationship should be collaborative/coordinated partnerships.
4	• The ideal is to have them standing separately, but meeting in regular fora (Nedlac is a good example), which is really useful. Institutions such as the NRF also provided useful opportunities for researchers to identify current needs of the state, and for the state to encourage specific directions of research.
5	• There should be an equal partners and they must work together to drive innovation at a local/regional level, for example in a regional innovation forum. • Participate in shaping the national policy debates on differentiation. • Government take a proactive stance advisory capacity.

As shown in Figure 8.8.1-1, among the respondents, 60% proposed that the relationship among the NSI actors should be strengthened through collaborative research, 40% proposed for shared national goals and participation of the actors in national policy making, while 20% indicated that the relationship among the NSI actor should stand at arm's length.

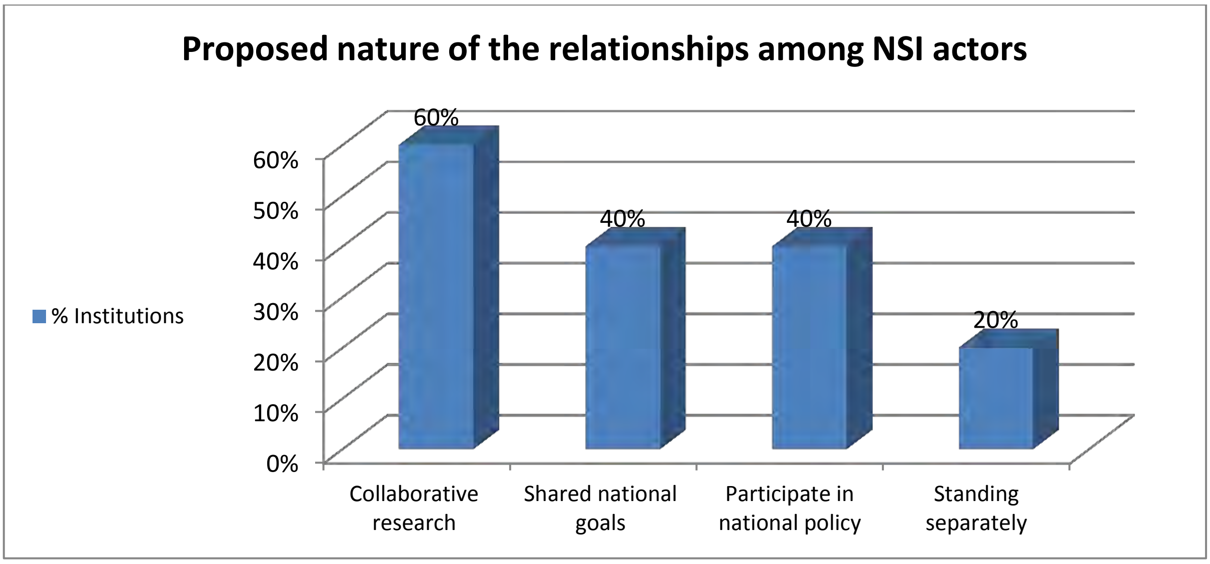


Figure 8.8.1-1: Proposed nature of the relationships among NSI actors

Discussion

The findings indicate the absence of a dedicated inter-sector collaboration programme. As a result the respondents proposed for collaborative research among the NSI actors. The respondents also proposed that the current *ad-hoc* collaboration should be replaced with effective platforms such as competence centres, thematic networks and transnational laboratories. Coordination among the NSI actors should be strengthened by establishing government-led structures to oversee the system-wide priorities and long-range planning for research and SD, supported by quality monitoring and strong evaluation and advisory capacity.

8.8.2 Main Weaknesses of the Relationship among the NSI Actors

From your institutional perspective, describe the main weaknesses of the above relationship

The main weaknesses facing the relationship between HEIs, the private sector and government is the lack of strategic leadership by the NSI actors, as shown in Table 8.8.2-1. In addition, the Fourth Respondent noted that within a global context, South Africa's poor economic competitiveness in certain sectors presents itself as one of the threats to HEIs in general.

Table 8.8.2-1: Main weaknesses of the relationship between the NSI actors

HEIs	MAIN WEAKNESSES OF THE RELATIONSHIP BETWEEN THE NSI ACTORS
1	• Working in silos, repeating research • No common goal or understanding • Business/Government only interested in working with the 'Ivy League' universities.
2	• One party does not know what the other party does (lack of coordination). • Needs and demands of the various parties are not fulfilled since there is no cooperation.
3	• Lack of role clarification and leadership • Lack of NSI clear direction • The lack of decision making particularly from government partners who often happen to have acting principals or managers that do not or cannot commit to partnerships. • The long time it takes to get decisions finalised from government partners. • Lack of skills in some sectors. • Poor economic competitiveness
4	• The current relationship works relatively well, however, poor competitiveness due to social issues facing South Africa • Skill shortage • Lack of technology and lack of machinery • Societal problems such as unemployment and crime
5	• Not coordinated, no single point of contact often duplicated. • There's no space, no networks existing for NSI dialogues to take place • Lack of strategic leadership • Lack of funding for start-ups

The Institutions stated the following reasons as the main weaknesses that have hindered the NSI linkages, which have been illustrated in Figure 8.8.2-1:

- Limited financial resources (100%)
- Lack of funding (100%)
- Lack of share NSI purpose (100%)
- Lack of human resources skills/resistance (100%)

The weaknesses are similar to the challenges facing HEIs research commercialisation efforts.

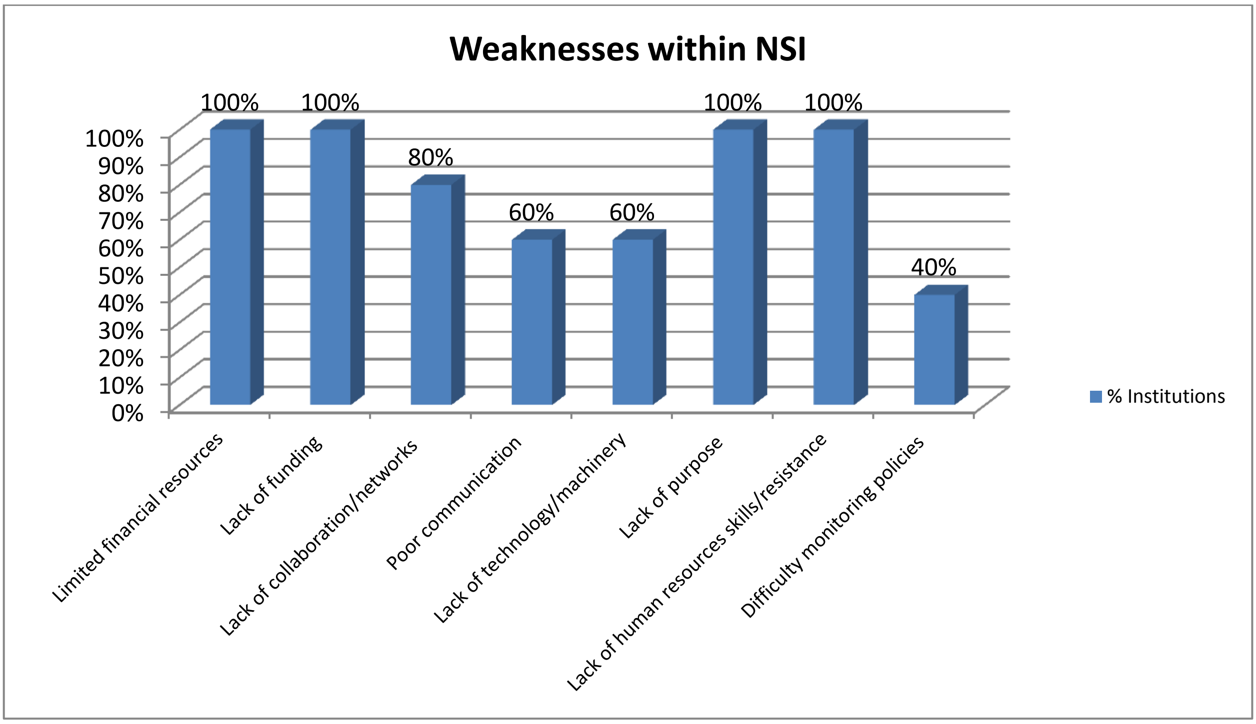


Figure 8.8.2-1: Weaknesses within NSI

Discussion

The findings indicate that the most common weaknesses among the HEIs and other NSI actors can be attributed to:

- Internal HEIs conditions such as inadequate research commercialisation skills and development.
- Lack of proper internal coordination.
- Lack of strategic leadership rather than on non-conducive external conditions such as lack of national policies or industry weaknesses.

These weaknesses suggest a strong recognition by respondents for the HEIs to take responsibility and action for strengthening their own internal capacity in order to strengthen the NSI relationship with the private sector. Furthermore, support for new business formation and research commercialisation is limited because the financial institutions and venture capitalists are risk-averse and reluctant to get involved at an early stage of commercialisation.

The findings also indicate that the HEIs are in the process of developing or implementing policies with respect to time spent on consultancy services and external activities, IP sharing, royalties, conflict of interests and environmental concerns, which have been largely absent from the HEIs.

8.8.3 Suggestions for Strengthening the NSI Relationships

What do you suppose should be done by the government, business/private sector and HEIs to strengthen the above relationship?

In general, the respondents proposed that collaboration activities should be undertaken to strengthen the NSI actors' relationship as shown in Table 8.8.3-1.

Table 8.8.3-1: Suggestions for strengthening the relationship among the NSI

HEIs	SUGGESTIONS FOR STRENGTHENING THE RELATIONSHIP AMONG THE NSI
1	• Form single research body in a province or area. • Government to increase coordination by making collaboration compulsory. • Made-to-purpose research should be done for all.
2	• To develop good working relationships collaboration whereby all the parties could have mutual benefit.
3	• Formalise partnerships contractually and ensure steering committees have clear mandate. • Manage on project management principles. • Technology incubators.
4	• Increase collaboration.
5	• Support regional innovation forums and incubators.

In strengthening the relationship among the NSI actors, Figure 8.8.3-1illustrates that 20% of the respondents indicated that collaboration and support for regional innovation should be increased within the NSI. 20% of the respondents indicated that a single research body and formalisation of partnerships should be undertaken.

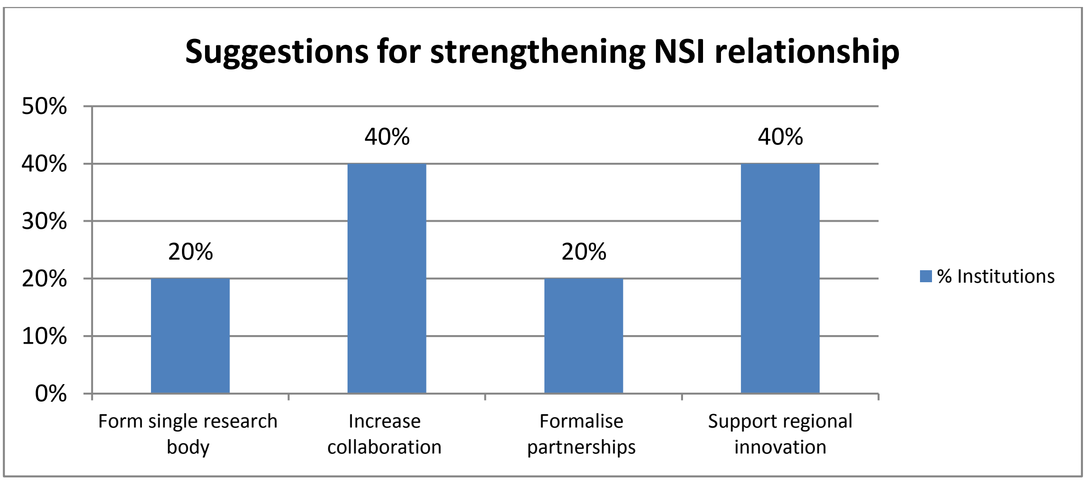


Figure 8.8.3-1: Suggestions for strengthening NSI relationship

Discussion

The government has little direct control over the private sector in respect of self-driven research. However, respondents indicated that the government should play a critical role in creating favourable framework conditions for research commercialisation and innovation and supporting mainstream policies to attain national objectives. The findings point out those exploring new forms of collaboration and complementarities among the HEIs and the private sector is vital for research commercialisation. The respondents suggested:

- Setting-up of collaboration and joint ventures by NSI actors to stimulate transfer of skills and knowledge.
- Creation of an interagency coordination mechanism by the government.
- Coordination of government policies should be improved.
- Establishment of common priorities for achieving coordination among different actors.

Strengthening the coordination of S&T policies across ministries could have the effect of pulling those policies out of their specific contexts in which S&T represents only one element.

8.9 SECTION 5: GOVERNMENT SUPPORT, FUNDING AND INCENTIVES

This section examines the nature of government funding, support and incentives for research commercialisation, SD and CE.

8.9.1 Funding Sources for Higher Educational Institutions

Describe the major sources of research funding in your institutions

The major funder of HEIs research funding is the public funding from the South African government science councils, as shown in Table 8.9.1-1. Other sources of funding include internally-generated, private sector funding, funds for capacity-building by donors and other external partners. Information regarding the actual amount of funding received from the various sources did not form part of this research. According to the respondents, funds from the private sector are most commonly given for graduate student research and scholarships, academic excellence awards, HEIs chairs and seed grants, industry-commissioned research and/or technology development and investments in laboratories and equipment.

Table 8.9.1-1: Major sources of research funding at the HEIs

HEIs	MAJOR SOURCES OF RESEARCH FUNDING AT THE HEIs
1	• Government subsidies, namely: MRC, ARC, NRF and Eskom • Belgium government/European Union funding
2	• The Government through the NRF • Staff study subsidies • Topping up fund • Matching and ad hoc grant/Seed funding • Free standing staff research grant
3	• Government subsidy for research outputs • NRF funding in a variety of programs • One of the largest beneficiaries of the THRIP program • MRC, TIA, other research councils • Foreign funding • Private funding/Sector
4	• NRF, Medical Research Council, • Foreign Government • International research funding agencies and donations • Private Sector funders (Major South African industry partners include the Eskom • Group, Anglo Group, Old Mutual, Rustenburg Platinum Mines, and the Sasol Group • scholarships and fellowships, • Through research contracts/National Institutes of Health
5	• Government subsidies, namely: MRC, WRC, ARC, NRF Eskom and Sasol • Private sector • Thuthuka Grant, TIA • Dedicated funding and tax breaks for spin-off, flagship by foreign funding

The NRF is the leading government institution that funds research at the HEIs as illustrated in Figure 8.9.1-1. The private sector is the second major source of funding of HEIs research.

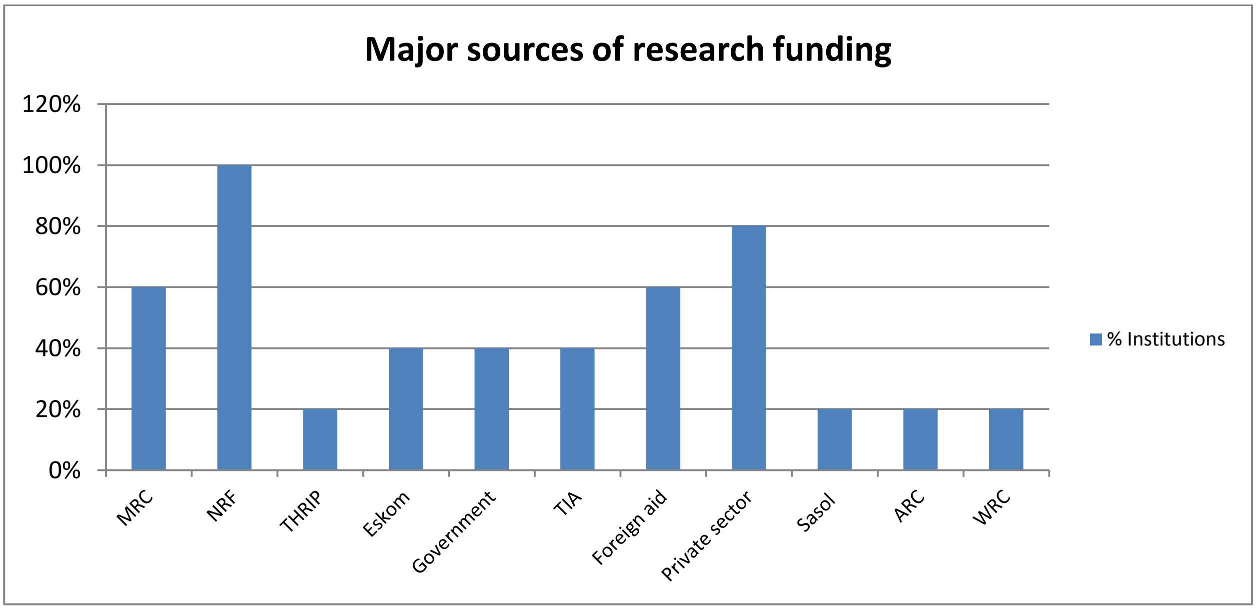


Figure 8.9.1-1: Major sources of research funding at the HEIs

Discussion

In 2009/10, General University Funds (GUF) – comprising own funds and the higher education vote – were the main source of funding (50.3%) for HERD (DST/HSRC, 2013) destined for both education and research. Nominally, GUF increased by 29.3% between 2008/09 and 2009/10, a year-on-year change from R1.984 billion (2008/09) to R2.566 Billion (2009/10). External sources combined contributed a total of 38.5% of the funding for research in higher education. Among the external sources, agency funding contributed 14.6% to higher education, followed by the domestic business sector at 11.9%. On the one hand, funding from science councils increased nominally, but showed a decline in the percentage distribution. On the other hand, funding from foreign sources showed an increase in the percentage contribution between 2007/08 and 2008/09 (from 8.8% in 2007/08 to 9.8% in 2008/09) and a decrease to 8.7% in 2009/10 (DST/HSRC, 2013).

The University of Cape Town (UCT) reported the highest R&D expenditure of R944 million in 2009/10, followed by the UKZN (R656 million) and the University of the Witwatersrand (Wits) (R631 million) (DST/HSRC, 2013). UCT also reported the highest number of researchers by headcount (2321) followed by the Wits (2102) and the University of Pretoria (2004). The HERD grew in nominal terms from R4.191 billion in 2008/09 to R5.101 billion in 2009/10, representing a 21.7% year-on-year increase (DST/HSRC, 2013).

The finding has shown that main funding for the HEIs comes from three different sources: the state budget through NRF, government ministries and departments, and external domestic and foreign competitive funding. Public funds for research are allocated via various mechanisms. Government funding made available to HEIs, through the DST, TIA, NRF, among others, runs on short-term cycles, in contrast to long-term orientated basic research for increasing the HEIs' national and global competitiveness with respect to Mode 1 knowledge production. Changes within the South African HEIs such as the emergence of new types of HEIs, changes in patterns of financing and governance, curriculum reforms and technological innovations have had an impact on funding.

Externally-funded projects in the form of international competitive flagships with the primary objective of contributing to direct SD at the local, regional and national levels also take place within the HEIs. However, unlike in the Nordic countries, South African traditional outputs (student numbers and research publications) funding formula for HEIs does not provide incentives to support 'third mission' (community engagement) types of activities. As long as the HEIs continue to rely on external research funding, there will be risks of the development of a skewed research agenda. However, a greater risk lies in shutting down funding opportunities, further eroding the research within the HEIs. Consequently, the priority requires strengthening of NRDS.

8.9.2 Proposed Government Support

In which ways can government support HEIs in facilitating research commercialisation?

Funding of research, NSI leadership role, policy development and providing workshops/forum ranked among the top government support required for research commercialisation (Table 8.9.2-1).

Table 8.9.2-1: Suggested government support in facilitating research commercialisation

HEIs	GOVERNMENT SUPPORT IN FACILITATING RESEARCH COMMERCIALISATION
1	• By discussing possible partnerships between private sector businesses • Commissioning research from HEI's that are broad enough for commercialisation • Developing policies • Building the research capacity
2	• Providing workshops and incubators • Increase funding • Develop and establish activities that are of interest to the institution • Ensure M&E of policies • Financing pilot projects • Awards for research pilot and commercialisation
3	• By supporting the various commercialisation efforts through start-up funding • TIA funding • Various forms of commitments • Research chairs • Further improvements in THRIP funding • Strengthen the "enterprise" character
4	• Facilitating the HEI into a 'research-led' institution • Improving dissemination of research • Increasing human resource capacity • Reward and incentives • Policy development and implementation
5	• Provide funding for an incubator • Regional and national coordination and support networks • Support SARIMA to build technology transfer/IP capacity • Support the regional innovation forum and agendas • Policy development, aligning research objectives, removes duplication • Support exchange programmes, Capacity development

The respondents were asked to state the most needed support from government to help enhance HEIs' research commercialisation. As shown in Figure 8.9.2-1, factors cited most by respondents were:

- Funding (60%).
- NSI partnerships roles (40%).
- Policy development (40%).
- Providing workshops /forum (40%).

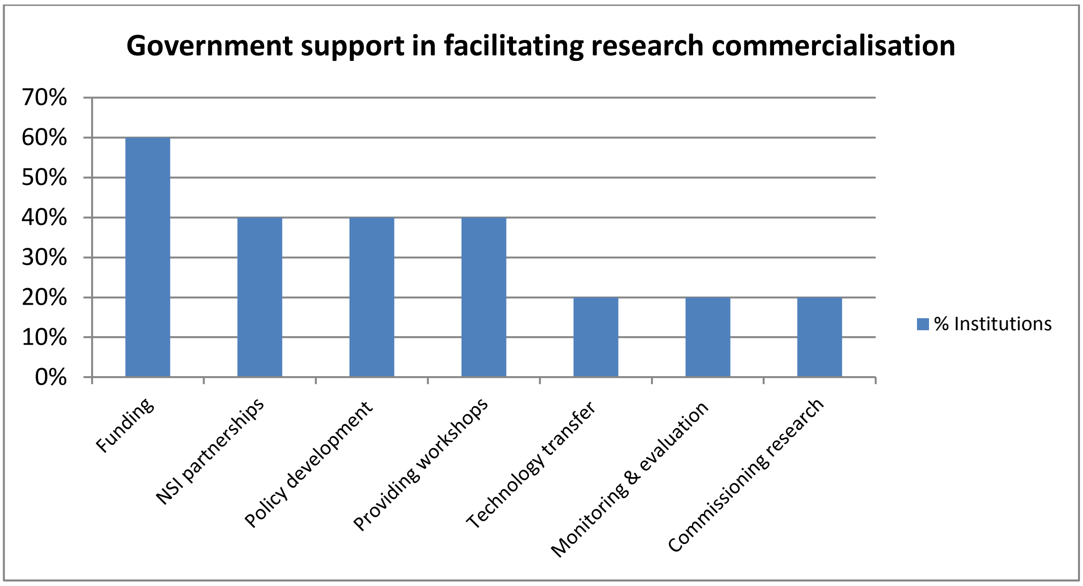


Figure 8.9.2-1: Suggested government support in facilitating research commercialisation

Discussion

The findings indicate that the government could support HEIs in research commercialisation by developing policies, organising research agendas and commitments to regional initiatives and providing incentives. Government support of regional and national innovation forums, agendas and support networks can increase research commercialisation through encouraging co-operation, collaboration, communication and learning. Furthermore, government support can ensure the removal of conflicting regulations or policies. Government can support HEIs by providing funding for incubator projects and financing pilot projects because lack of funding is a highly publicised barrier to achieving both research commercialisation and SD. Few HEIs appear to have established commercialisation infrastructures and are dependent on government's technology incubators. The respondents indicated that appropriate qualifications and skills such as IP expertise, business and project management skills are critical for research incubators to yield benefits to both HEIs and industry. Although the development and implementation of IP policies does not appear among the immediate priorities, such policies are required for effective governance of incubators.

The government could also provide support to HEIs through research projects, strategic planning and training, increasing human resource capacity as well as providing rewards and other incentives which can assist in removing the silo mentality cited by respondents and increase interdisciplinary research. The innovation policy could take place in the form of introduction of a set of "third generation" instruments for supporting public/private partnerships on breakthrough technologies such as nanotechnologies.

8.10 QUANLITATIVE DATA ANALYSIS (INTERVIEW)

This section presents the research interview findings.

8.11 COMMUNITY ENGAGEMENT AND SUSTAINABLE DEVELOPMENT

Which are most common types of CE activities conducted in your institution?

The most commonly conducted CE activities presented in Table 8.11-1 were: (i) organising seminars and workshops on industry-related issues; (ii) conducting short courses for industry human resources; and (iii) providing consultancy services to enterprises.

Table 8.11-1: Community engagement and sustainable development activities at HEIs

HEIs	COMMUNITY ENGAGEMENT ACTIVITIES
1	In the process of finalising CE policy document. The institution has a memorandum of understanding with government, which is different in different faculties such as • Assisting community members with dentistry by the school of medicine • Law students helping community members to understand and interpret the law • Journalism and business school teaching business skills to community members • Engineering assist community members with various skills such as electricity • Education sector training outsiders, Assisting in agriculture, Teaching and advice in business and Financial management with banks to uplift the neighbouring region
2	• CE policy document is integrated into the research document, but will have to stand on its own at a later stage. CE initiatives for example in the rural development hub • Faculties have various CE activities and initiatives , such as one funded by the Swedish government, which conduct longitudinal studies, tackle issues such as health, obesity, teacher education, sustainability studies, food sources- production of chicken
3	• In September 2011 adopted a new CE strategy to replace previous CE strategy • Undertakes activities linked to research, Work integrated learning and special projects • CE Partnerships includes: Tears programme, training and support of lay-counsellors, The Rainbow Foundation, buddy programme for quadriplegics, Platinum Metals Group for specific corporate social investment projects among others • Partnership to assist local communities in the ICT context
4	• The institution has in place a CE document • Air pollution and sustainable fishing, park conservation and human wildlife conflict • Research commercialisation in different areas is taking place at the institution for example in engineering such as chemical and electrical engineering • NRF supports sustainability issues in conjunction with HEIs • Foreign government such as Sweden (SANPAD)
5	• The institution has in place a CE document • Engaging in mutually beneficial partnerships locally, nationally and globally to enhance social, economic, and ecological sustainability

Discussion

The findings have shown that most of the HEIs have a CE policy document in place, while others are in the process of developing and finalising a policy framework for CE. Furthermore, the HEIs are utilising their knowledge and skills for CE, for building the capacity of others and for stretching the traditional boundaries to support meaningful CE. According to the third respondent, engaging in CE is part of research activities as research articles should be produced as a result. The CE activities in the HEIs appear to be part of SD process in the form of social and environmental pillars. The HEIs stressed that CE should be linked to research and teaching, not, for example, related to 'supporting' or 'fund raising'.

The HEIs reward structures follow traditional public funding models based on student and research outputs. However, it is unlikely that substantial amounts of resources would be allocated to incentivise academics to further and directly contribute towards CE at the local, regional and national level(s) given the financial stringency facing both the government and the HEIs. The Third Respondent acknowledged the role of foreign and external donors in sponsoring specific projects with SD elements (staff and student engagement) and community outreach benefits (measurable outputs).

8.12 HIGHER EDUCATIONAL INSTITUTIONS COLLABORATIONS

Which are most commonly reported collaborations with the regard to private sector?

The respondents indicated the presence of active collaboration with the private sector in mining, manufacturing and pharmaceutical sectors, as shown in Table 8.12-1. According to the third respondent, mechanical engineering students assist the automotive industry across South Africa to become more innovative and globally competitive.

Since 2002, the engineering students have actively collaborated with 240 SMMEs across 80 specific projects, including industry players like General Motors, Daimler Chrysler, Ford and Volkswagen. Customer fees vary on the basis of a governmental subsidy table, from 90% to 0% subsidy. The revenue generated is re-invested in infrastructure, with 15% going directly to the HEIs. According to the Institution Four, in 2012, 1218 contracts to the value of R682 million were signed, involving both local and international funders.

Table 8.12-1: HEIs collaborations with the private sector

HEIs	COLLABORATIONS WITH THE PRIVATE SECTOR
1	• Integrated learning in the private sector of students • Collaboration with other HEIs • SAICA – setting exams, job placement, accounting skills
2	Includes partnerships and collaborations with • Eskom- research going on • Ned bank chair in accounting • Land bank chair in selected areas • Collaborating with the Mining industries with the HEIs • Close relationship with the banking sector • Use of computer technologies with the private sector • Technological assistance to business
3	• Advice to small and medium-sized businesses • Development of patent into product • A Regional Innovation Structure Office was conceptualised and will support the Innovation Clusters • Anglo Gold Ashanti and the National Development Agency- training of trainers • Potch/Tlokwe Business Chamber collaborated in Food bank, ‘Trees for Cansa’ fundraising project and ‘Stop begging’ campaign • “Ages” a company that hosts the Touching Africa Development Trust and explored collaboration and disseminate information on dolomite and training workshops
4	• Research commercialisation in different areas is taking place at the institution in collaboration with the private sector for example in engineering such as chemical and electrical engineering
5	• Partnerships with the private sector • Regional for a taking place

The HEIs have made attempts to engage with diverse partners, as shown in Table 8.12-2. The partners include international organisations, science research councils, manufacturing and service industry and associations, chambers of commerce and banking institutions, state corporations, transnational and multinational local corporations, and small, medium micro-sized enterprises (SMME). The challenges facing the NSI require strengthened cross-boundary collaboration and TT between actors in the system namely: the government, the private sector, HEIs and civil society.

Table 8.12-2: HEIs collaborations with the NSI actors

HEIS	COLLABORATIONS WITH THE FOLLOWING SECTORS AMONG THE NSI
1	• Agriculture and agribusiness
2	• To develop good working relationships collaboration whereby all the parties could have mutual benefit
3	• Formalise the partnerships contractually and ensure that steering committees have clear mandate • Manage on project management principles
4	• Agriculture and fishing and environmental issues • Engineering for example mechanical and chemical • Information communication technology
5	• Diverse Environmental areas • Engineering • Information communication technology

Table 8.12-3 shows that the majority of HEIs have made, at least, initial efforts to foster and institutionalise linkages with the private sector via the creation of designated posts and offices.

Table 8.12-3: Most commonly reported HEIs collaborations with the private sector

MOST COMMONLY REPORTED HEIS COLLABORATIONS WITH THE PRIVATE SECTOR	% RESPONDENTS	NO. OF RESPONDENTS
• Agriculture and agribusiness	60%	3/5
• Environmental management	60%	3/5
• Information communication technology (ICTs)	40%	2/5
• Engineering for example mechanical and chemical	40%	2/5

The major HEIs-private sector collaborations are further illustrated in Figure 8.12-1, which shows most active collaborations were: agriculture and agribusiness (60%), environmental management (60%), ICTs, (40%) and engineering (40%). All the respondents implied that efforts to break down inter-sector boundaries are required for increased research commercialisation.

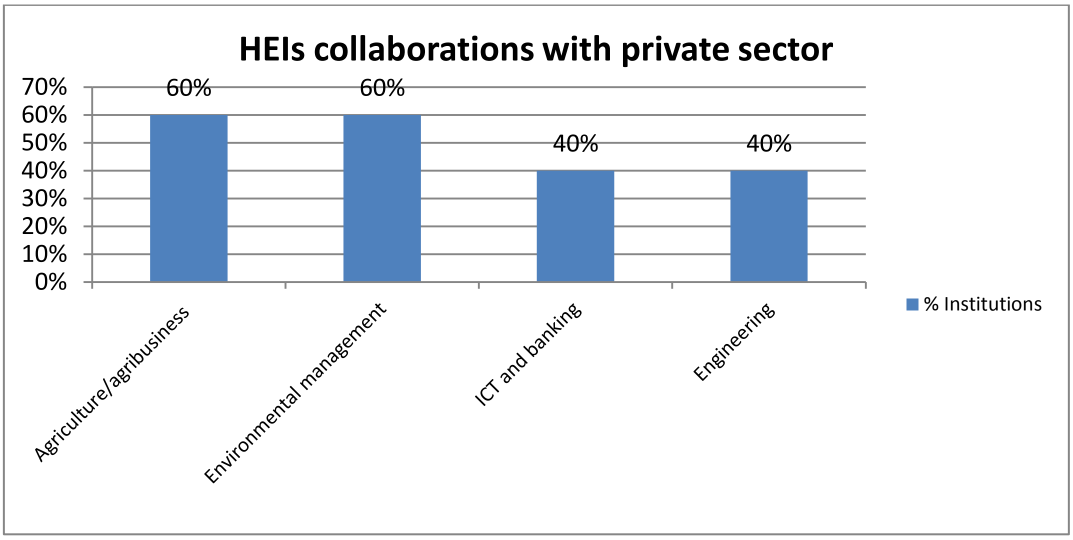


Figure 8.12-1: Reported HEIs collaborations with private sector

Discussion

The findings recognise the value of collaboration, linkages and partnerships for knowledge transfer and exchange within the NSI. The HEIs are responding to the new private sector collaboration role and expectations, despite the challenges highlighted by the respondents. While the institutions referred to the current linkages as weak, measures are being taken to strengthen institutional capacity to support HEIs-private sector linkages. All the respondents have or are in the process of deploying a range of HEIs-private sector collaborative research programmes for long-term commercially relevant research.

The HEIs-private sector linkage occurs in various forms that involve different engagement intensities. First, the linkages occur in the form of R&D, training and curriculum development and academic planning. Second, the linkages take place in the form of student attachments and employment opportunities for HEIs graduates. Third, HEI-private sector collaborate in the form of consultancy and professional courses on a fee-basis, defining student research projects, promotion of technology transfer, and sponsoring of university research chairs. Fourth, the collaboration takes place in the form of engaging in joint R&D, prototype development and business services such as testing and certification, technology incubation. Fifth, HEI-private sector collaborates in the form of creation of spin-off, licensing and royalty agreements, supporting development-oriented technology transfer for local communities, organising seminars and workshops on industry-related issues.

Two of the five institutions have been able to secure essential financial gains from research commercialisation through HEI-private sector collaborations, while, in contrast, three of the five institutions have generated only marginal or no income from such research commercialisation and industry partnership activities.

The respondents' have recognised agriculture/agribusiness and the informal sector as significant in South Africa's development. The respondent HEIs have made significant impact on local entrepreneurs and communities, the agricultural sector and development-oriented technology transfer, which are major contributors to the South African economy. As such the contribution of the HEIs should not be measured narrowly in terms of HEIs-private sector/formal sector. Rather, it should be measured equally with the HEIs role in promoting productivity gains throughout the larger sector, including agriculture and the informal economy. Nevertheless, mining also accounts for a large proportion of the private sector in South African, with a few HEIs engagement, mainly due to geographical issues.

The respondents' implied that both formal and informal future collaborations should be utilised to leverage new and existing knowledge and provide professional skills and training. The NSI collaborations should also be used to increase the benefit of research scale capabilities and capacity as well as provide for joint authorships. HEIs-private sector should also collaborate to match knowledge supply and demand, fund joint research projects and laboratories and commercialisation of research results. Also, the role of HEIs-private sector engagement should be utilised to provide financial support for spin-offs, standardise practices, increase communication and support for inter-sector mobility of resources. The collaboration theme provides an important pointer, both in research commercialisation and SD practices. Government initiatives that bring the HEIs-private sector relationship to the centre stage are required to market the HEIs as potential industry problem-solvers.

8.13 BENEFITS OF ENGAGING WITH PRIVATE SECTOR

What are some of the benefits (tangible and intangible) for engaging with the private sector in terms of research commercialisation, community engagement and sustainable development at your institution?

An outline of the tangible and intangible benefits accruing to the HEIs as a result of engaging with the private sector is set out in Table 8.13-1. According to the interview responses, benefits in the form of funds from the private sector were most commonly given in the form of student scholarships, academic excellence awards and graduate student research. Other forms of benefits included sponsorship of HEIs chairs and seed grants, industry-commissioned research and technology development and investments in HEIs laboratories and equipment.

Table 8.13-1: Tangible and intangible benefits of engaging with private sector

HEIs	BENEFITS OF ENGAGING WITH PRIVATE SECTOR
1	• Financial assistance and funding • Rural integrated learning • Employment of students
2	• Supporting events as the HEIs • Placement and jobs for the students
3	• Relevance of the university, increased prestige • Programmes (research and CE) knowledge base makes the university very relevant • Financially beneficial in terms of Income, Earning royalties • Earning CE throughput where the University is a key player • Opportunities for networks Staff and students benefit. In terms of the students placements, which allows them to know the private sector better and allow students better career choice and network that allows staff to further their expertise • Social entrepreneurship • Influence of research agenda coming from the collaborative efforts private sector • Meaningful investments
4	• Students' employment and placement • Postgraduate research • Funding of research
5	• Students' research • Placement

Discussion

The findings have shown that major tangible benefits accrued as a result of collaborating with the private sector, including: (i) networking and access to industry partners; (ii) access to industry laboratories and equipment; and (iii) journal publications. Benefits that have occurred, to a lesser extent, include: (i) ownership of licenses or patents; and (ii) the creation of spin-off/start-up companies.

Intangible benefits have included an increase in HEIs' prestige as a positive externality of engagement with the private sector, enhanced graduate employability, skills development and internship opportunities and increased contribution to community development. Intangible benefits that have occurred, to a lesser extent, include increased publications and networking, and enhanced revenue for the institution and staff.

8.14 OPTIMISATION OF RESEARCH VISION

In general, how has your institution optimised its research vision in terms of sustainable development and commercialisation of research?

Various suggestions by the respondents that could be used to optimise the HEIs research vision in terms of SD and commercialisation of research are presented in Table 8.14-1. Some of the HEIs have been affected by the effect of merger/orientation to increase in research effort and activities required.

Table 8.14-1: Optimisation of research vision

HEIs	OPTIMISATION OF RESEARCH VISION
1	• Very low research productivity, the programme is more technical than research, because of effect of merger/orientation, increase in research effort and activities are required.
2	• Achieved through conducting research.
3	• Optimised through setting research goals. • Collaborating with community.
4	• Entailed undertaking research and research commercialisation activities.
5	Research optimised through: • ICT incubators • Engineering and science • Arts

Discussion

The findings indicate that most of the HEIs are yet to fully realise their research visions. The respondents highlighted funding issues as problematic, with funds (public and private sources) going directly to individual academics, rather than to strategic projects or research teams. For example, the NRF funding supports individual academics, rather than research groups.

Whereas most of the HEIs are faced with the challenge of an ageing cohort of established researchers nearing or entering retirement, the Institution Four noted that a flagship research development and support initiative of Emerging Researcher Programme (ERP) has reached the tenth year since its inception in 2003, which has proven to be successful in growing and nurturing the next generation of academics.

8.15 FACTORS FOR RESISTANCE OR LACK OF RESPONSIVENESS

What are some of the factors that account for resistance to or lack of responsiveness to sustainable development and commercialisation of research?

In general according to the respondents, lack of funding and training has indirectly accounted for resistance or lack of responsiveness to research commercialisation and SD initiatives, as shown in Table 8.15-1. Other notable factors include the lack of knowledge, training, and finance required for SD and commercialisation of research.

Table 8.15-1: Factors account for resistance or lack of responsiveness

HEIs	FACTORS ACCOUNT FOR RESISTANCE OR LACK OF RESPONSIVENESS
1	• Negative responsiveness is present due to ignorance by academics on issues such as SD, CE and research commercialisation
2	• Positive responsiveness is present and the academics are willing however: o Lack of knowledge o Lack of training o Lack of finances o Limited opportunities of funding
3	• Due to overload of work. • Research "burden' you do not publish you perish, staff feel the pressure • Lack of alignment/ Integration of CE with core university business • Volunteerism is lacking • CE plays second role due to lecturing responsibilities followed by laboratory responsibilities
4	• There is a positive responsiveness; on the contrary institutional members are actively embracing the concept of SD, CE and commercialisation of research
5	• Positive responsiveness is in place, only challenges such as: o Funding o IP registration polices and benefits and o Time constraints o Inadequate research infrastructure

Discussion

Eighty percent of the respondents indicated that the HEIs are responsive to research commercialisation and SD needs in South Africa. However, all the respondents stated challenges that act as barriers to staff being more responsive, *viz* as ignorance, work load (teaching and administrative responsibilities) and limited funding. The overall pressure, therefore, is for the HEIs to be more responsive to business needs, more relevant to the immediate and wider communities, operate and act as catalysts for the development of knowledge regions and be relevant to wider national economic, societal and environmental issues and development.

8.16 CHALLENGES/WEAKNESSES FACING HIGHER EDUCATION

What are some of the challenges/weaknesses facing your institution within the NSI?

Generally, the respondents indicated that the mandate to commercialise research and establish HEIs-private sector partnerships is a relatively new function for many of the HEIs, a function which was previously undertaken on an *ad hoc* basis. Table 8.16-1 presents the challenges/weaknesses pointed out by the respondents, which range from financial to human resource constraints.

Table 8.16-1: Challenges/weaknesses facing HEIs within the NSI

HEIs	CHALLENGES/WEAKNESSES FACING HEI WITHIN THE NSI
1	• Lack of understanding by community members of the importance of engagement, especially short term engagements • Lack of finance and funding • Over-centralised decision-making and bureaucracy • Lack of understanding of IP issues, research commercialisation and SD/CE issues by academics • Lack of proper and fair incentive mechanisms by HEIs to staff
2	• Issue of trust and suspicion by community, there is a need to build trust • Language challenge- three national languages • The need of insiders in the community depending on where you want to engage and conduct research • Racial issues
3	• Skill shortage • Funding challenges • Academic overload with teaching responsibilities
4	• China and foreign markets pose a threat • Ideas from South Africa are in a much better position to be commercialised in other countries • Skill shortage • Lack of technology and lack of machinery • Societal problems and challenges such as crime and poverty have impact • Overreliance on personal links rather than institutional links to the business sector
5	• Giving too much away of ideas before innovation • Deserve more feeling

Discussion

The interview responses generally indicate that the intricacies of IP management have acted as a major weakness in research commercialisation, which is not well understood by many South African institutions in the NSI sector. The objectives of a TTO are often questioned and patenting is seen as a high-cost endeavour. The results show that mentors and training opportunities are few and far between and practitioners are forced to learn by trial and error, rather than by means of good practice. According to the findings, the reason for the low patenting and licensing in HEIs include: (i) limited expertise/low capacity in IP management; (ii) lack of requisite commercialising experience and skill; (iii) lack of access to research laboratories and up-to-date equipment; and (iv) machinery for commercialisation to take place.

The Institution One noted that funding and reward mechanisms can encourage the process of research commercialisation. Achieving high level research will require a systematic and long-term development of potential IP research units and rewarding researchers fairly for SD, CE and research commercialisation activities. The absence or, conversely, presence of internal capacity of staff or professionals with relevant entrepreneurial experience and research skill has emerged as a key factor in hindering or enabling HEI linkages with the private sector. The demand for training in research commercialisation, IP management and entrepreneurial skills will directly respond to the constraints identified by the respondents and represent an important avenue for strengthening linkages between the HEIs and other NSI actors. The Institution also noted that research in the post-merger institutions will depend on finding an adequate balance (focus) between vast arrays of responsibilities facing the institutions.

The Institution Five stated that "academics lack the trust of 'giving away too much' of the invention at early stages", which has a negative effect on research commercialisation. The lack of sufficient incentives to disclose inventions as well as conflicting objectives among the actors have further impeded research commercialisation. The Institution stated that:

> "*there should be some internally coherent manner in which basically the structure the academic profile of the institution so that it is not just an amalgam of loose entities that hang together, but something much more internally, cognitively and organisationally coherent. They would essentially conduct R&D for the private sector core coherent and strategically more coherent as well*".

The challenges facing the HEIs research require strengthened collaboration within and across all key sectors- government, the private sector, HEIs and general public, which is still limited.

8.17 AREAS OF POLICY SOLUTIONS/SUGGESTIONS FOR THE GOVERNMENT

What are some of the areas of policy solutions/suggestions for government in support the HEIs contribution to sustainable development and research commercialisation?

Policy suggestions outlined in Table 8.17-1 by respondents indicate that the overall level of resources devoted for research commercialisation by the government is low. As such areas of policy suggestions include support for sabbatical arrangements/exchanges with the private sector, recognition awards for industry-related research and encouragement of entrepreneurial activities. Other policy suggestions mentioned were monetary bonuses, promotion based on industry-related research, access to special funds and access to seed grants for commercialising outputs.

Table 8.17-1: Areas of policy solutions/suggestions to the government

HEIs	AREAS OF POLICY SOLUTIONS/SUGGESTIONS TO THE GOVERNMENT
1	• Market the HEIs • Policies and procedures by government to 'force' staff to undertake SD and research commercialisation • Provide sabbatical • Treat SD and research commercialisation as a project • Teach project management skills • Increase funding • Proper funding can open up opportunities and strengthen research commercialisation and SD
2	• Long term policy measures • Integration of commercialisation and research • Integration of public sector, private sector, the government and society
3	• Integration of SD, CE and research commercialisation should take place. • Government to fund collaborative funds between Private sector and society (community), which is being done through THRIP and NRF
4	• Massive education of public should be undertaken • Civic awareness to the public, private sector on HEIs relevance
5	• Capacity building • Funding for research • Support for SARIMA • Government not to duplicate roles, there should be clarity of roles • Government should be empowering • Government set incubators

Discussion

Both the questionnaire and interviews findings indicate the government should ensure that:

- South Africa has in place a set of institutions, organisations and policies that give effect to the various functions of the NSI.
- There is a constructive set of interactions among those institutions, organisations and policies.
- There is in place an agreed upon set of goals and objectives consonant with an articulated vision of the future which is being sought.

According to the respondents, successful uptake of HEIs innovation will rely on increasing the demand-side of the equation by the government and stimulating uptake from the private sector. The Institution Three also noted that THRIP industry-public researchers' linkage programme should be expanded further to a target of double its present level.

In general, the respondents implied that increasing research commercialisation and SD initiatives will require locating the HEIs centrally within the government research policy development and implementation.

Similarly, increased funding by the government will provide extra sustainable ways of increased capacities through massive initiatives. The new funding drivers should be well structured and constituted through consultative forums. The government will also have to identify sector-specific strategic priorities for research and innovation agendas. In addition, governance of South Africa's NSI and research will require mechanisms to promote knowledge transfer and exchange, such as networking, dissemination and internationalisation.

The respondents expressed dissatisfaction with the current government research model. In this regard, the model should be revised to permit optimisation, integration and coordination within common policy frameworks. The revised model will have to be strategically-directed and applied across all the significant components of, and contributors to, the NSI.

However, policy makers should not impose a standardised, micro-managed policy governance model on the HEIs. The establishment of friendly policy governance architecture is imperative to achieving common NSI actors' vision and coordinating activities.

8.18 POLICY SUGGESTIONS AND ACTIVITIES FOR THE HIGHER EDUCATION

What are some of the areas of policy solutions/suggestions for the HEIs for sustainable development, community engagement and research commercialisation?

The respondents provided various policy suggestions outlined in Table 8.18-1. They observed that the HEIs should create policies suited at increasing research productivity. The private sector and HEIs collaborations should also be enhanced to improve knowledge transfer and networking.

Table 8.18-1: Policy solutions/suggestions for the HEIs within the NSI

HEIs	POLICY SOLUTIONS/SUGGESTIONS FOR THE HEIS WITHIN THE NSI
1	• Develop and implement policies that are user friendly for supporting and facilitating SD and research commercialisation • Treat SD and research commercialisation as a project, requiring project management skills
2	• Research aimed at regional needs • Policies for strengthening the HEIS, private sector and government • Increasing staff and funding • Increasing research commercialisation efforts
3	• Increasing collaboration between the HEIs and private sector and government in the triple helix model • Increased staff development • Implementation of various policy mixes
4	• Policy awareness programmes for staff • Increased support for staff
5	• Research management policies • Increasing skills and training for staff • Support research capacity

Discussion

The findings indicate that the HEIs need to develop policies focusing on research commercialisation. Strategic leadership was identified as critical for research commercialisation and SD. The Second Respondent stated that "'we are many things and we have many cultures and many mind-sets". The interview complements earlier questionnaire policy suggestions for the HEIs, which include strengthening of research governance and improved funding model. Furthermore, HEIs-private sector collaborations and partnership and contracted research were cited as significant for research commercialisation and SD.

8.19 "NEXT STEPS" PLANNED FOR STRENGTHENING HIGHER EDUCATION

What "next steps" have you planned at your HEIs to strengthen commitment to sustainable development, community engagement and research commercialisation?

The respondents observed that strengthening IP management will be a crucial "next step" for research commercialisation and SD as shown in Table 8.19-1. The respondents also recognised patents and copyrights as *de facto* measure of research commercialisation.

Table 8.19-1: "next steps" planned for strengthening HEIS within the NSI

HEIs	"NEXT STEPS" PLANNED FOR STRENGTHENING HEIS WITHIN THE NSI
1	• Proper policies in place • Second staff into these "projects" • Emulate other institutions emulate leaders in HEIs
2	• Publications and identifying niche, relevant research • Strengthening patenting • Triple helix strengthening the relationship

3	• The underlying strategic intent of research, innovation and CE activities at the HEI is to achieve and maintain quality and relevance.
	• Research Entity development trajectory is as follows
	  o Level 1: undertake Research Niche Area
	  o Level 2: undertake Research Focus Area
	  o Level 3: form Research Unit
	  o Level 4:establish Centre of Excellence
	• Relevance will be achieved by aligning research and innovation strategies with national and international challenges, within the capabilities and capacity, in line with DST 10 year Innovation Plan, The MDGs, and the research and innovation needs of various State Departments, such as the DTI, DoH, DME, among others
	• Improve the research profile in terms of total research output, the qualification profile of staff, productivity and focused excellence in order to position the HEI among the top six universities in terms of total research and innovation output

4	• Massive education of public should be undertaken • Civic awareness (courses should be undertaken to the public) • IP policy awareness and initiatives
5	• Increasing staff • Increasing research commercialisation • Strengthening IP/TTO areas

Discussion

The results indicate that the lack of separate policy documents on SD, research commercialisation and IP management has had a negative impact on HEIs research productivity and commercialisation. However, it is unclear whether HEIs lack the capacity to formulate and enforce these policies or simply do not consider them a priority.

8.20 EMERGING CATEGORIES: QUESTIONNAIRE AND INTERVIEWS

The emerging categories, sub-categories and themes for the construct of SD in South Africa from research commercialisation in the NSI are presented in the Table 8.20-1. The emerging themes from the questionnaire, interviews and participating HEI strategic documents have been used in developing the framework.

Table 8.20-1: Emerging categories for the construct of sustainable development

CATEGORY	SUB-CATEGORY	THEMES
1. Contribution to SD 2. SD policy	• Engage in greening projects • Partnership • Entrepreneur • Community engagement • Resource assessment • Research policy • Leadership • Engagement	• Competent graduates/scholarship • Enrols students from disadvantaged social backgrounds • Charges low fees/low income • Work-integrated learning activities • Caters to needs of the societies • Vision and mission
3. NSI Challenges and weaknesses	• Monitoring and implementation of policies • Financial resources/management • Funding • Human resources skills • Time • Poor communication • Strategic leadership	• Collaboration • Cooperation • Expertise
4. Research commercialisation 5. Role of HEIs within NSI 6. Innovation and responsiveness	• Solution-driven research • Technology Transfer • Knowledge creation and sharing • Research commercialisation • IP	• Collaboration • Consultancy
7. Funding sources 8. Government support 9. Strengthening NSI relationships 10. IP	• Government subsidy • Foreign governments • Partnerships • Technology transfer • Innovation support office • Grants and contracts	• NRF/THRIP • Funding • Commissioning research • Monitoring and evaluation • Collaboration • Partnerships/Forums • Project management

Table 8.20-2 outlines the emerging themes which are represented in seven categories. The seven categories relate directly to the objectives of the core functions of South Africa's HEIs, namely: (i) organisational (ii) research; (iii) CE; (iv) campus/college; (v) students; (vi) teaching and; (vii) staff. The categories constitute the strategic priorities or critical success factors that should be addressed by the HEIs in a holistic manner for SD through research in the NSI.

Table 8.20-2: Summary and interrelationships between the seven categories

SUMMARY AND INTERRELATIONSHIPS BETWEEN THE SEVEN CATEGORIES	
Core Functions of participating HEIs	1. Teaching and Learning 2. Research and Innovation 3. Community Engagement
Enabling Conditions	4. Transformative Institutional Culture 5. Human Capital Development 6. Financial Viability and Sustainability 7. Vibrant Campus/College Environment and Modern Infrastructure

Based on the findings, the 'HEIs organisational objectives' were identified as the first category outlined in Table 8.20-3. Important statements expressing organisational objectives include: an affirming institutional culture, opportunities for human capital development, sustainable financial resources, modern infrastructure, streamlined and efficient institutional systems and processes. In order to increase research productivity for SD the HEIs should actively embrace unwavering commitments to all the three (economic, social and environmental) pillars.

Table 8.20-3: Summary statements expressing HEIs organisational objectives

ORGANISATIONAL OBJECTIVES STATEMENTS EXPRESSING ORGANISATIONAL OBJECTIVES		
Ambition	**Agent for change**	**Example**
• Contribute to regional SD by reflecting and serving a diverse regional, national and global communities • Offer a diverse range of quality educational opportunities that will make a critical and constructive contribution to regional, national and global sustainability	• Encourage mutually beneficial and sustainable approaches to community service and engagement • Drive transformation as an integrated, urgent, fair and well-managed process of fundamental and sustainable change to address institutional inequalities while accounting for the needs of the South Africa	• Properly manage natural resources for today and future generations • Have integrity on SD • Promote the integration of sustainability into the academic practices, institutional operations and design of physical infrastructure. • Implement expertise in teaching-learning, research, commercially and community-directed, for the benefit of Southern Africa, the region, the continent and the world

The organisational objectives or strategic priorities constitute key pillars or critical success factors that should be addressed as the enabling conditions in teaching, learning, research and engagement. The Institution Five noted that the HEI's mission, vision and values revolve around engagement.

However, there is a lack of clarity on the specific differences between engagement and the traditional service function of HEIs. In general, engaged HEIs incline more on Mode 2 of vocational, practical training as well as applied research aimed at enhancing the employment of graduates and tackling regional and national needs of the economy. However, the engagement and impacts of HEIs activities are much more ambiguous and indirect than is advocated by instrumentalist perspectives conception of HEIs as 'engines' for economic growth and development. The willingness to become an 'engaged institution' results, amongst other aspects, in the building of bridges (linkages) with a wide variety of external NSI actors.

The second emerging category identified relates to the HEIs' research objectives summarised in Table 8.20-4. The respondents acknowledged the role of HEIs as knowledge-intensive institutions within the NSI that should strive towards the generation of IP of many kinds to facilitate the commercialisation of research and increase the number of patents developed.

Table 8.20-4: Summary of statements expressing research objectives

RESEARCH OBJECTIVES STATEMENTS EXPRESSING RESEARCH OBJECTIVES		
Ambition	**Agent for change**	**Example**
• Create and sustain an environment that encourages and supports a vibrant research, scholarship and innovation culture • Align research focus areas to national priorities and institutional strategic objectives and capacity	• Institutions will partner with major donor and granting agencies and key international universities to advance research thrusts. • Seek to attract postgraduate students in niche areas, nurturing them to become private researchers	• Initiate strategic R&D partnerships to broaden and deepen engagement with the economy • To increase quality and quantity of research through focus in terms of campus niches, appropriate incentives and capacity building and development, while strengthening the quality of teaching and learning by improved client focus, electronic learning, innovation and diversity

The third emerging category identified relates to CE objectives, which are summarised in Table 8.20-5. The respondents acknowledged the importance of having clearly set objectives that recognise, promote and reward responsible CE and add value to local, regional and national development.

Table 8.20-5: Summary of statements on objectives related to community engagement

OBJECTIVES RELATED TO THE LOCAL COMMUNITY STATEMENTS ON OBJECTIVES RELATED TO THE LOCAL COMMUNITY		
Ambition	**Agent for change**	**Example**
• Contribute to the prosperity and sustainability of the various South African provinces, and to nation-building, through CE • Develop formal training for HCD outside of the HEIs	• Foster strategic partnerships • Provide a platform for bringing scholars together to create new knowledge	• Recognise, promote and reward responsible CE that adds value

The fourth emerging category is summarised in Table 8.20-6. It relates to statements concerning to the HEIs campus or college objectives. In general, the respondents indicated that the realisation of campus/college objectives will require establishing increasingly integrated planning systems. The process will require an alignment between the institutional strategic plan, resource allocation and budgeting models, M&E mechanisms, quality advancement and Performance Management Systems (PMS).

Table 8.20-6: Summary of statements related to objectives for the campus or colleges

OBJECTIVES RELATED TO THE CAMPUS OR COLLEGES STATEMENTS RELATED TO OBJECTIVES FOR THE CAMPUS OR COLLEGES		
Ambition	Agent for change	Example
• To establish the HEIs to attract and retain academic and support staff of the highest calibre by creating an intellectual environment that fosters and stimulates academic life, and a climate of organisational citizenship	• Streamline administrative and decision-making processes in line with SD • Implement an effective and transparent planning and budgeting cycle • Be a tool for transformation and change. Adopt innovative approaches to promote excellence • Be a social entrepreneur	• Be rewarded for green teaching, research or activism • Promote, recognise and reward excellence in teaching, learning, research and engagement • Co-ordinate the review, optimisation and implementation of policies, processes, procedures and systems that support the core business, towards the establishment of an inclusive culture based on the value system of the HEIs

The HEIs' fifth emerging category relates to students, as shown in Table 8.20-7. The category relates to the need to develop education, skills and training initiatives at all levels in South Africa. However, South Africa is still confronted by a 'skills deficit', indicating a material mismatch between education and training outcomes and the requirements of the modernisation theory. To close this gap, the respondents widely agreed that solutions are needed for the effective and efficient functioning of HEIs.

Table 8.20-7: Summary of statements on objectives related to students

OBJECTIVES RELATED TO STUDENTS STATEMENTS ON OBJECTIVES RELATED TO STUDENTS		
Ambition	**Agent for change**	**Example**
• Ensure that a suitably enabling environment is created for students, conducive to the creation of a balanced student experience as regards academic, social-cultural and sports activities; and also in terms of the development of students into leaders	• Provide improved opportunities for lifelong learning and continuous professional development for a diverse range of learners through diversifying the current modes of delivery and intensifying strategies to implement blended or e-learning	• Be adaptable, influence change, apply SD in all aspects and engage in lifelong learning • Develop, educate and empower through innovative and high-quality teaching-learning, well-rounded graduates • Ensure conducive environment to the creation of a balanced student experience as regards academic, social-cultural and sports

A proactive role by South African HEIs is crucial for building a sustainable FET sector and addressing skills shortages in the economy. The sixth emerging category outlined in Table 8.20-8 and relates to the HEIs' objectives on teaching. This category indicated that in the area of teaching, the HEIs are expected to provide excellent teaching and learning programmes in a comprehensive range of undergraduate and postgraduate programmes.

Table 8.20-8: Summary of statements on objectives of teaching

OBJECTIVES RELATED TO TEACHING STATEMENTS ON OBJECTIVES OF TEACHING		
Ambition	**Agent for change**	**Example**
• Be transformative and have SD integrated into all endeavours	• Provide excellent teaching and learning programmes in a comprehensive range of undergraduate and postgraduate programmes	• Encourage and reward excellence, innovation, creativity and scholarship in teaching and learning

The DST TYIP (2008) identified the need to increase the number and improve the equity profile of the next generation of researchers and academics in South Africa. However, the TYIP mission is a pressing demand given the ageing profile of the professoriate in South Africa and "brain drain" caused by the emigration of highly skilled academics and researchers. Contribution of the HEIs to the TYIP 2008 and NDP 2030 national objectives will require the progressive increase in postgraduate enrolments and dealing with equity issues. An analysis of enrolment trends from 2005 to 2009 in South African HEIs indicates that progress has been made in this respect since the total postgraduate headcount enrolments have increased at an average annual growth rate of 5.4%. According to the DST/HSRC (2013), the year-on-year change in the headcount of postdoctoral fellows between 2008/09 and 2009/10 showed positive growth of 24.6%. An increase in doctoral headcounts was also recorded, from 10 376 in 2008/09 to 10 761 in 2009/10, and in masters student headcounts from 25 524 in 2008/09 to 26 956 in 2009/10. In terms of the gender representation of total postgraduate student headcounts for 2009/10, males accounted for 52.4% and females 47.6%.

Table 8.20-9 is a summary of the seventh emerging category that relates to the HEIs' objectives on staff. This category indicates it can be reasonably expected that increasing pressure will be placed on HEIs human resources to ensure that programme offerings, research endeavours and engagement interventions make a substantive contribution to addressing development priorities.

Table 8.20-9: Summary of statements on objectives related to staff

OBJECTIVES RELATED TO STAFF STATEMENTS ON OBJECTIVES RELATED TO STAFF		
Ambition	**Agent for change**	**Example**
• To establish the HEIs to attract and retain academic and support staff of the highest calibre by creating an intellectual environment that fosters and stimulates academic life, and a climate of organisational citizenship	• Identify, recognise, reward excellence and develop the full potential of staff	• Be recognised SD academics. • Ensure that the principles of good corporate governance underpin HEIs operations

The seven interrelated categories are shown in Figure 8.20-1. These categories and accompanying activities are generally linked, interdependent, synergistic and integrated. For purposes of providing a diagrammatic representation of the HEIs engagement conceptual framework and typology, the integrated categories and activities have been separated. The seven interrelated categories (Figure 8.20-1) have been structured according to the basic distinction between what the HEIs do (activities) and what the HEIs are able to do (capabilities). The seven emerging categories have further been sub-categorised in terms of four priorities areas, namely: (i) teaching and learning; (ii) research; (iii) CE and; (iv) sustainability and competitiveness.

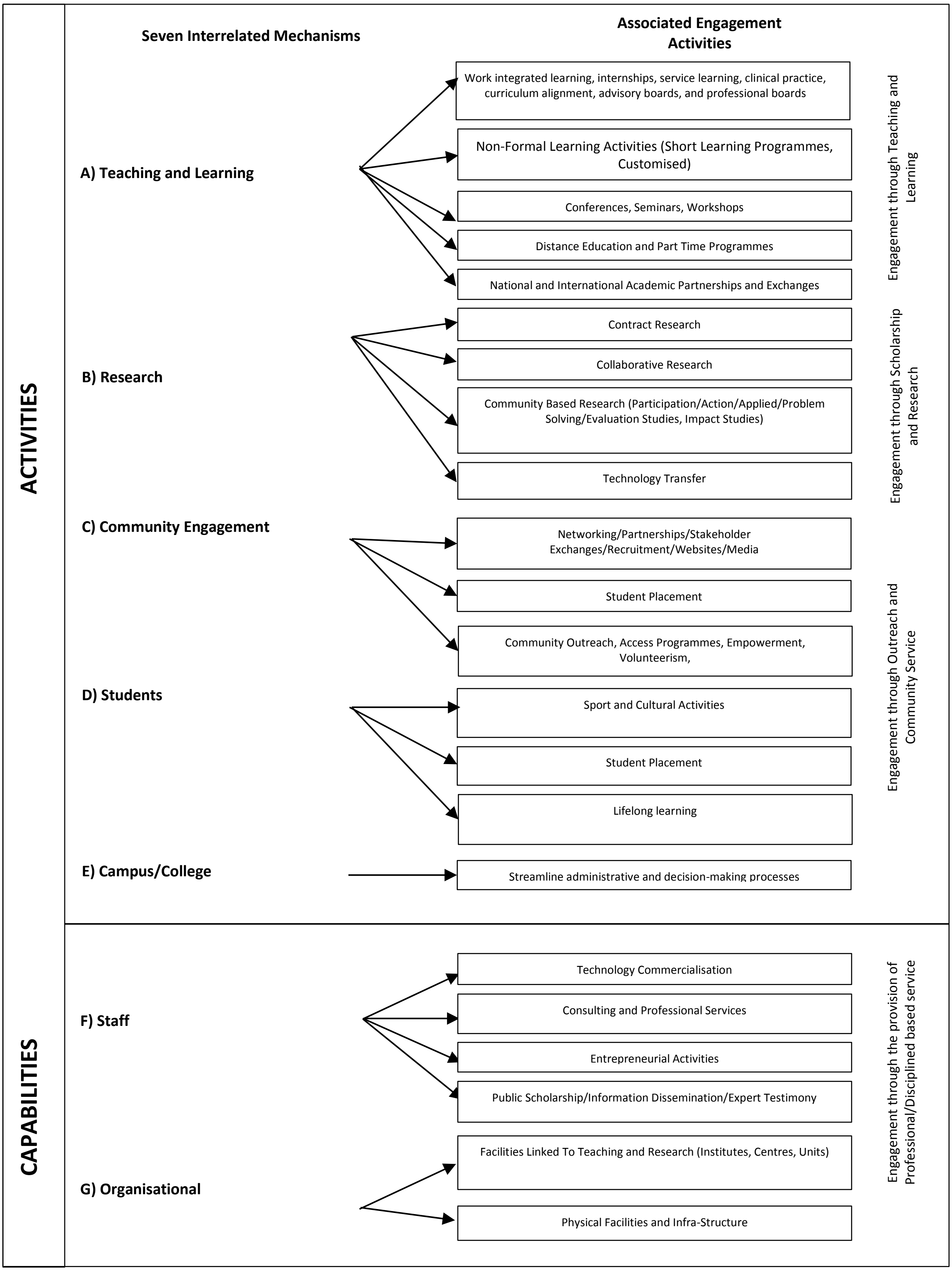


Figure 8.20-1: Summary of the seven emerging categories at the HEIs

A summary of the first strategic priority that relate to teaching and learning and the accompanying strategic priorities, strategic objectives, inputs and indicators are presented in Table 8.20-10. The summary shows that the HEIs intend to promote critical scholarship and develop well-rounded and responsible graduates for the proposed knowledge economy.

Table 8.20-10: Strategic priority 1: Teaching and learning

1. STRATEGIC PRIORITY 1: TEACHING AND LEARNING THAT IMPACT ON STAFF			
STRATEGIC PRIORITY	**STRATEGIC OBJECTIVES**	**INPUTS**	**INDICATORS**
1a. Promotes critical scholarship and develops well-rounded and responsible graduates for the proposed knowledge economy	1. Develop and implement strategies to enhance HEIs responsiveness to regional, national and global SD 2. Develop and implement integrated planning systems at all HEIs levels	• Undertake annual environmental scan • Review HEIs Programmes and Qualification Mix (PQM) • Master plan to promote development	• Matrix of identified opportunities and development needs • Approved PQM and infrastructural master plans • Number of mission-critical posts filled annually and high retention rates
1b. Design and implement a range of access routes as well as progression and articulation strategies and qualification pathways	3. Review current access routes and programmes and develop mechanisms to coordinate, evaluate impact, and expand range if necessary 4. Design and implement flexible modes of delivery and access routes into the existing HEQF curriculum	• Gap analysis and review of existing access routes and programmes • Progression and articulation rules included into appropriate academic programmes	• Range of programmes appropriate to meet students' needs. • Success rates of learners enrolled in programmes using flexible modes of delivery. • Recording and monitoring of credit
1c. Design and implement institutional frameworks for academic programme planning and review and curriculum transformation	5. Develop and implement a process and framework for curriculum development and transformation to align the HEIs academic programmes with vision, mission and academic 6. Design and implement a system for academic programme planning and review to ensure the quality and responsiveness	• Review and consolidation of academic programme portfolio • Revise and streamline Policy and Procedures • Approve and implement framework for curriculum development and transformation	• Monitored Service Level Agreement (SLAs) to support programme planning and review • Extent of implemented recommendations contained in formal review reports • Impact assessment of curriculum transformation projects undertaken
1d. Create and sustain a responsive learning environment conducive to excellence in teaching and learning	8. Build relationships, develop and implement strategies to support students to progressively assume responsibility for their own learning 9. Promote effective pedagogy and assessment practices, including	• Report activities on Student Orientation Programme (SOP) • Interventions to assist students • Attend lectures • Develop and implement	• Number of activities that foster academic and social integration • Percentage of lectures and performance rates • Percentage of students reported

1. STRATEGIC PRIORITY 1: TEACHING AND LEARNING THAT IMPACT ON STAFF			
	technology-assisted learning	strategies for electronic learning	application of theories or concepts
1e. Empower staff and students to use technology as a normal part of mainstream teaching and learning provision, processes and practices in a blended learning environment	10. Business and teaching and learning process enablement through ICT. 11. Access to specialist computing resources in support of academic and research requirements 12. Develop and implement appropriate technology-based, integrated media services and infrastructure	• Unified wireless communications platform for data and rich media applications, with central management • ICT process enablement	• Efficient & effective storage, search, retrieval, collaboration, dissemination & archiving of information • No. of staff & students with network access to VoIP services
1f. Develop a brand that positions the HEIs as employers of choice	13. Develop and implement systems and processes to value growth, development and employee advancement 14. Establish a unique employer brand	• Post-merged institutional culture integration • Attraction and Retention Plan • Competitive remuneration strategy	• Comprehensiveness & relevance of benchmarking analysis • Number of talented employees attracted and retained annually
1g. Implement and monitor programmes to enhance human resources development transformation	15. Develop a formalised strategic workforce planning process to provide workforce capability to ensure that employees are able to meet current and future business objectives	• Principles and practices of equity and diversity integrated into all aspects of human resources policy, practices and programmes	• % participation in various leadership & management development programmes • Leadership effectiveness survey

The first HEIs strategic priority shows that attempts have been made in various degrees to align teaching and learning to SD in the local and regional contexts as well as in South Africa as a whole.

A summary of the second strategic priority relating to research, scholarship and innovation is presented in Table 8.20-11. The Institution Two stated that "we want, in our core functions, to be in a sense informed by research, and not necessarily research intensive". The strategic priority indicates that the HEIs' strategic plans reveal some internal willingness to address SD as a product of research in the NSI in line with South Africa's policy imperatives.

Table 8.20-11: Strategic priorities that relate to research, scholarship and innovation

2. STRATEGIC PRIORITY 2: CREATE AND SUSTAIN AN ENVIRONMENT THAT ENCOURAGES, SUPPORTS AND REWARDS A VIBRANT RESEARCH, SCHOLARSHIP AND INNOVATION			
STRATEGIC PRIORITY	**STRATEGIC OBJECTIVES**	**INPUTS**	**INDICATORS**
2a. Conduct research that contributes to local, regional, national and global sustainability	1. Establish and expand research partnerships, collaborations, networks and linkages nationally and internationally 2. Promote the commercialisation of research outcomes in the form of products, processes and services. 3. Identify and develop institutional research themes	• Strategic partnerships, collaborations, networks and linkages established with academic institutions, private sector, government agencies and NGOs. • Research Centres of Excellence • Research Chairs	• Number and impact of international partnerships/collaboration • Networks/linkages • Number of Research Centres of Excellence • Number of Research Chairs • Number of Research Entities aligned to the research themes.
2b. Create and support an environment that fosters research quality and productivity	4. Provide an enabling policy and funding framework to researchers to improve research quality and productivity 5. Provide appropriate research and innovation infrastructure and support 6. Promote, recognise, and reward research and innovation excellence 7. Increase and diversify external and internal financial resources available to support research-related activities	• Percentage of time allocated to research. • Guidelines for the management and improvement of quality and research • Appropriate rewards and incentives for excellence in research, innovation. • Diversified funding sources for research • Increase in external and internal research funds	• Percentage of time on research • Proportion of research outputs produced by academic staff • Number of journal articles published in DoE, international, national list and accredited publications. • Appropriate research and technology equipment • Number of funding sources for research. • Number of strategic partnerships with relevant external stakeholders
2c. Develop and sustain the research capacity of staff and students	8. Attract, nurture, develop research potential and provide support to emerging researchers, postgraduate students and postdoctoral fellows to become research active 9. Enhance and improve the equity, gender and age profile of researchers 10. Grow the pool of NRF-rated researchers. 11. Promote a broad conceptualisation of research, scholarship and innovation	• Increase funding available to support postgraduate students • Appropriate research development initiatives • Improve research supervision capacity of academic staff. • Increase number of NRF-rated researchers retaining or improving the rating	• Proportion of academic staff with PhDs • Number of sustained initiatives to attract & support development of emerging researchers. • Number of competent postgraduate supervisors & mentors • Improved completion rates of postgraduate students • Number of academic staff with NRF rating. • Proportion of research outputs produced by previously disadvantaged

Table 8.20-12 is a summary of the HEIs third strategic priority relating to CE. This strategic priority indicates that at the institutional level, community-orientated activities are not viewed as strategic, given their lack of an academic basis. Traditional teaching and research are (still) the two elements that academics are accounted for and evaluated.

Table 8.20-12: Strategic priorities that relate to community engagements

3. STRATEGIC PRIORITY 3: HEIs SUSTAINABLE FUTURE THROUGH COMMUNITY ENGAGEMENTS			
STRATEGIC PRIORITY	**STRATEGIC OBJECTIVES**	**INPUTS**	**INDICATORS**
3a.Develop and sustain mutually beneficial local, regional and international partnerships that contribute to a sustainable future	1. Stimulate, support, recognise and reward engagement at all levels of the institution. 2. Foster and sustain partnerships with donors, funding organisations and alumni 3. Develop a recognition system for staff and students (individuals and collectives), which encourages excellence, innovation, responsiveness and active participation in HEIs life	• Update database of partnerships based on engagement categories. • Increase international partnerships/collaborations linked research, teaching and learning and exchanges. • Cordial relationships with sponsors and alumni established and sustained • Comparative benchmarking	• Extent of alignment of partnerships and engagement • Number of international strategic research, teaching and learning partnerships. • Number of partnerships with donors • Number of active alumni database
3b. Embrace and reflect reciprocal and nurturing engagement with internal and external communities	12. Create mutually beneficial and sustainable relationships with internal and external communities 13. Build and maintain stakeholder networks. 14. Promote democracy, respect for human rights 15. Strengthening partnerships	• Develop and approve concept paper on the meaning of sustainability and CE • Develop and approve policy framework outlining engagement with diverse external stakeholders	• Evidence of link between engagement, teaching and learning and research • Recognition and reward for engagement
3c. Foster a excellence, innovation and sustainability	16. Adopt a reflective approach on institutional praxis to promote SD, excellence and innovation	• Incorporate reflexive praxis principles. • Benchmark best practices implemented	• Approved policy framework • Implemented quality assurance

There are currently more than 300 CE projects running at the third institution, which include: Mosaic project, Holding Hands Project part of the FLAGH Programme (Farm Labour and General Health), Health services, Youth Entrepreneurial Development Unit, Legal services to the community and Siyakhulisa Early Childhood Development Programme. The institution also undertakes expertise activities such as short courses, consultation, service rendering and technology transfer to generate third-stream income. At Institution Four, CE initiatives include Ubunye, a student-run development agency, the Safety and Violence Initiative, the Schools

Improvement Initiative, the African Climate and Development Initiative, and the Poverty and Inequality Initiative. At the Institution Five, CE activities include the social marketing/mobilisation for Transnet's Phelophepa Health Care Train and Women Development and Cleaning Co-operatives. The three strategic priorities, namely: (i) teaching and learning; (ii) research and; (iii) CE have further been reviewed with regard to CE activities at the HEIs, as shown in Table 8.20-13. At the HEIs, responsibility for planning, initiating and managing engagement activities resides with faculty or colleges. This kind of decentralised, but integrated, approach to planning and managing activities allows for the centralisation of certain engagement management and support functions.

Table 8.20-13: Summary of four categories of CE activities at the participating HEIs

OUTREACH AND COMMUNITY SERVICE	PROFESSIONAL/DISCIPLINE BASED SERVICE PROVISION	TEACHING AND LEARNING	RESEARCH AND SCHOLARSHIP
• Graduate Placement • Networking • Careers Open Days • Clinical Service • Volunteerism • Media Consultation • Outreach programmes to under serviced communities • Counselling • Socio-cultural activities	• Consulting and professional services • Partner in socio-economic projects • Contribute to public debate/Conferences • Partnerships with local and national agencies • Research based policy recommendations • Expert testimony • Public scholarship • Technology Commercialisation	• Service Learning • Work-integrated/Based learning/Clinical Practice • Discipline related Volunteerism • CPD/Customised Programmes/SLP`s • Part-time off-campus programmes • Project based learning • Internships • Clinical Practical • Conferences	• Participatory • Action Research • Applied Research • Collaborative Research • Professional Services • Technology Transfer • Contract Research • Evaluation and Impact studies • Problem analysis and solving

A summary of the fourth strategic priorities that relate to sustainability and competitiveness is summarised in Table 8.20-14. The priority entails the development of an integrated long-term financial plan that is responsive to HEIs' strategic abilities to promote sustainability and competitiveness. This priority further seeks to ensure the efficient and effective utilisation of assets and resources and increased awareness of health and wellness. Institution Three noted that the overall prevalence of HIV in the institution (students and staff) is low, 0.9% compared to the HEIs sector average of 2.9%. The low figure at the Institution indicates that the integrated institutional health and wellness strategy of the institution is effective. The HEAIDS (2012) research indicated a prevalence of 9.9% among university service staff, 4.4% among administrative staff, 1.5% among academic staff, and 3.4% among students in the higher education sector.

Table 8.20-14: Strategic priorities that relate to sustainability and competitiveness

4. STRATEGIC PRIORITY 4: HEIs DEVELOPMENT STRATEGY TO ENHANCE LONG-TERM SUSTAINABILITY AND COMPETITIVENESS			
STRATEGIC PRIORITY	**STRATEGIC OBJECTIVES**	**INPUTS**	**INDICATORS**
4a. Develop an integrated long-term financial plan that is responsive to HEIs strategic priorities and promotes sustainable growth. **4b.** Implement models to prioritise identified strategic initiatives	1. Identify initiatives that will support the attainment of institutional strategic priorities and goals in a sustainable manner. 2. Determine income streams and cost implications (capital, operating, staffing) of identified/proposed strategic initiatives	• Use resources efficiently • Prioritise a list of identified initiatives according to approved policy. • A business plan per initiative with defined income and cost implications	• Approved priority list of strategy-aligned initiatives • Business plans submitted as percentage of identified priorities
4c. Grow and diversify income streams to support the attainment of HEIs strategic objectives	3. Optimise student fees and subsidy income 4. Secure more robust alternative revenue streams	• Improved success rates • Subjects/programmes • Competitive fees • Income from 3rd stream revenue	• Change in net income from fees and subsidy • Percentage improvement of success rate
4d. Ensure efficient and effective utilisation of institutional assets and resources (academic, HR, financial, infrastructural) to enhance long-term financial viability	5. Develop and implement models to promote strategy-aligned, financially viable operations and eliminate system inefficiencies 6. Improve institutional processes, systems and infrastructure	• Approve and implement business models for all key operations to enhance financial viability • Efficient and effective cost management system	• Number of approved and implemented business models • Improvement in service levels • Utilisation of venues as % time
4e. Increased awareness of health & wellness benefits through participation in sport & recreation activities	7. Implement integrated approaches that promote comprehensive staff and student health and wellness on all campuses/colleges	• Review and integrate existing college life • More HIV+ persons accessing care and support services	• VCT uptake by staff and students • Number of HIV+ accessing support
4f. Develop and implement a framework for the management of HESs infrastructural and environmental resources.	8. Implement an accredited environmental management (IEM) system for planning and managing infrastructural projects, facilities and natural resources	• Environmentally-friendly products and processes used for infrastructure projects. • Good environmental management ratings	• Optimal utilisation of venues • Expenditure environmentally-friendly products and processes

8.21 COGNITIVE MAP DEVELOPMENT

In this research, Cognitive Mapping has been used to allow a great deal of data collected to be summarised in such a way that allows for interrelationships to be emphasised among the categories, sub-categories and themes. The use of Cognitive Mapping has provided visual assistance and diagrammatic representation to structure the complexities embedded in the construct of SD through research in the NSI. As an additional technique to facilitate the framework development, Cognitive Mapping has been used to provide links within the construct under investigation with a relative hierarchy of ideas. Furthermore, Cognitive Mapping has been used as a mental representation to describe mental images for encoding knowledge and information for summarising and communicating data and information.

Cognitive Mapping has provided this research with a non-linear way of organising notes and key ideas to emphasise interconnection of concepts to support details. The central topic has been placed in the middle of the page and the main ideas related to it put on branches that directly connect to the central topic. The details, which support these ideas, have been directly and indirectly linked to the main ideas and thereby to the central topic.

The cognitive map, shown in Figure 8.21-1 provides a broad visual representation of the categories, sub-categories and themes that emerged from the research analysis, which has been utilised in thinking about and conceptualising that data. The cognitive map of the data collected indicates the relationships (interrelatedness) of the categories, sub-categories and themes identified in the previous section.

The emerging building blocks for the proposed framework have been referred to as categories and indicated in bold, for example, Internal Environment which, in turn, has a relationship with Capacity, Funds and Expertise as indicated by the arrows in both directions. The Internal Environment also influences Research commercialisation. Cognitive Mapping, therefore, clearly shows that Research commercialisation (main construct) needs (interrelationship) Knowledge creation and Sharing (category), which has a direct relationship with and influences the External Environment (category), but that it also influences policies, support, funds (sub-category) and the Human Resources theme. Saturation of the cognitive map indicates the emergence of new information for addressing the research questions.

COGNITIVE MAP FOR SUSTAINABLE DEVELOPMENT THROUGH RESEARCH WITHIN THE NSI

Figure 8.21-1: Cognitive map for sustainable development through research within the NSI

8.22 FRAMEWORK DEVELOPMENT

The proposed framework is intended to strengthen South Africa's NSI SD based on commercialisation of research in the NSI. Generally, frameworks exhibit the internal interactions of the functions inside the organisation as well the interactions of those functions with the external environment. Based on the findings and the cognitive map, Figure 8.22-1 presents the proposed framework for SD through research within the NSI.

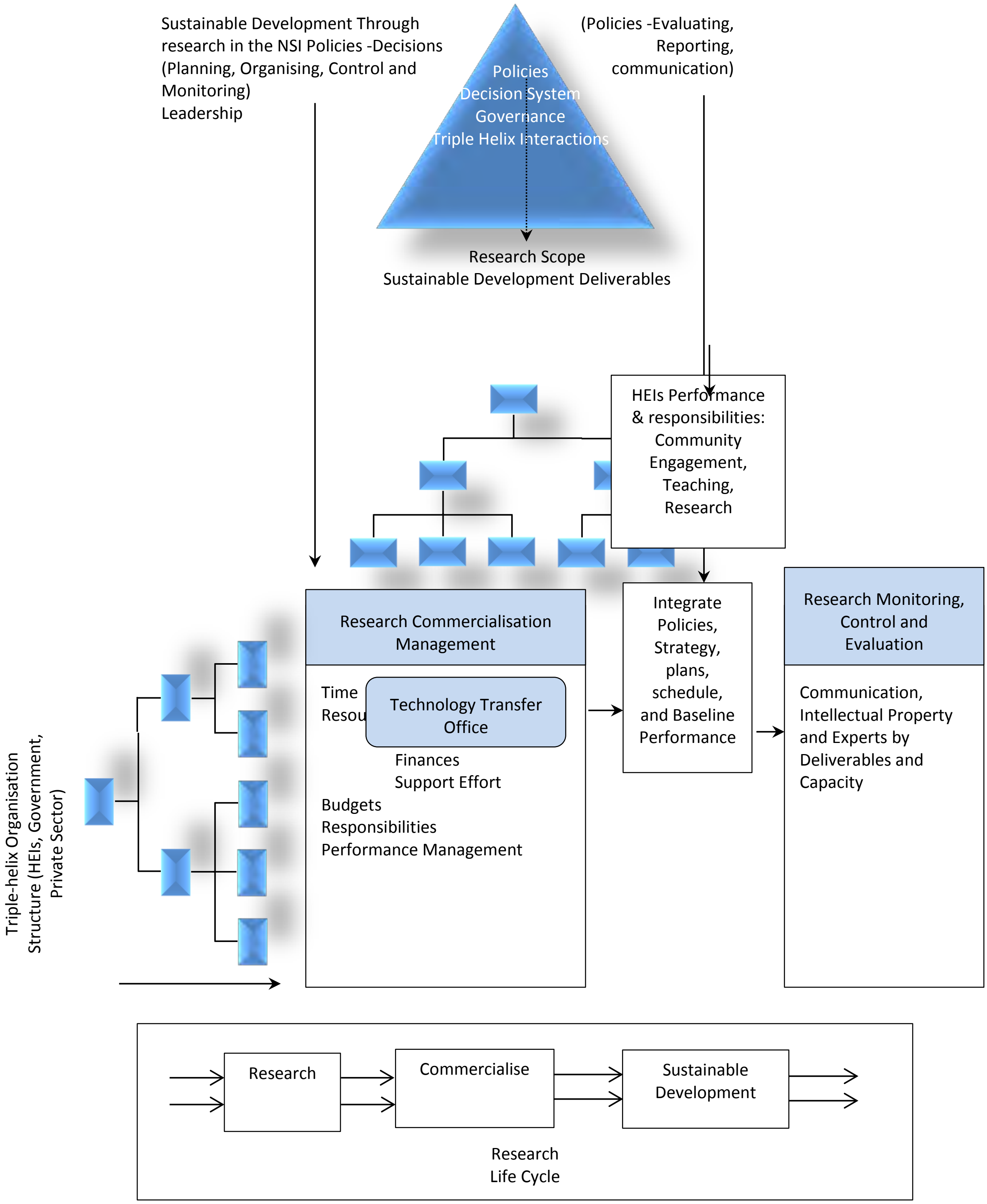


Figure 8.22-1: Proposed framework for sustainable development through research within the NSI

The proposed framework spans a range of NSI relationships. The anticipated components of the framework could be used to inform the work of the government, research, private sector and community of scholars in drawing inferences and providing policy advice, for example in addressing the 'wicked challenges'. A critical element in the NSI framework is the interconnectedness of the agents in the system, linking the common innovation infrastructure to specific clusters. Edquist (1997:18) states that "system of innovation should be looked upon as a 'whole' because many of its elements are – more or less closely – related to each other. Otherwise there would be no 'system'. The emerging key themes identified from the categories and sub-categories in Figure 8.22-1 are:

- NSI Leadership
- NSI Policies (Planning, Decisions-making, Organising, Control and Monitoring)
- NSI Governance
- Monitoring, Control and Evaluation
- Triple helix Organisation Structure (HEIs, Government and the Private Sector)
- Research Commercialisation Management
- SD Deliverables
- Performance and responsibilities: CE, Teaching and Research
- NSI Communication

NSI Leadership:

Leadership in this context is viewed as the ability to inspire people to make a total, willing and voluntary commitment to accomplishing or exceeding NSI organisational objectives. The respondents expressed disappointment with the universal, one-size fits-all NSI leadership and suggested a more contingent approach. In this regard, implications beyond policy measures will require national leadership to play its role in South Africa. An effective leader is one who responds to realities "incrementally" and also defines a general strategy and responds to settings and situations that present themselves. The findings suggest the importance of strong relationship between innovation and transformational leadership. Policy-makers' leadership should exhibit transformational leadership, which has a positive impact on the diverse NSI stakeholders. Transformational leaders motivate followers by increasing awareness of the importance of work done and engage in behaviours such as idealised influence, individualised consideration, inspirational motivation, and intellectual stimulation. From this perspective, substitutes for leadership include structured and routine policy tasks, intrinsically satisfying work, established formal rules and policies, and feedback that comes directly from the work, like automatically generated progress reports. In dealing with NSI professional networks, government executives and policy makers should give serious consideration to the individual competences (skills, knowledge) during policy making and implementation process. The strengths, components and collaboration of the NSI will depend on compelling leadership qualities that require collective, deep investment at both institutional and personal levels.

NSI Policy (Planning, Decision-Making Organising and Reporting)

In strengthening the NSI character, the findings identify that the NSI requires deliberate and well-informed attention in the form of research and planning, policy and programmatic interventions and M&E. The South African government's involvement is a critical component of development whether in planning, services, construction and infrastructure or managing the NSI actors' demands. The findings also suggest policy making is a cycle involving planning, implementation, evaluation, learning and adaptation. Research and performance reporting will involve the collection and dissemination of performance information on NSI resource usage. Furthermore, a variety of decision-support tools should be developed for policy-making based on evidence-based information for strategic analysis.

NSI Governance

The findings indicate that the South African government has a responsibility for firstly, setting out the role of government departments in pursuing the function and goals of the NSI. Second, the government should play a critical role and positioning of HEIs and training as well as the science councils within the NSI. Thirdly, the government should optimise the role of the major non-state actors (private sector, civil society and community-level groups) in the NSI. This research places the prime responsibility of the NSI on the South African government to ensure optimal functionality. The effective and efficient overall governance of the NSI is required for improving the performance of the individual parts and, at the same time, for ensuring the proper interconnectedness and coherent parts of the system. Governance within the HEIs will be required for developing appropriate models of institutional governance in the post-merged HEIs. Overall, it is the responsibility of the government to ensure effective implementation of an effective, strengthened and coordinated governance framework.

Monitoring, Control and Evaluation

There is an argument to be made for a strong integrated monitoring, control and evaluation capacity to be established, dedicated to informing the future strength and direction of the NSI. However, policy integration is not the consolidation of policies to create a single integrated policy dealing with everything. Discrete policy areas are a helpful way for separating policy actions that should integrate smoothly among the policy areas. The findings have identified a range of possible roles and responsibilities involving combinations of strategically configured evaluations of the performance of the system and its constituent agencies. Nevertheless, the government should play an instrumental role in the NSI policy cycle.

Triple Helix Organisation Structure

Within the triple-helix model, the actors contribute in stimulating and strengthening NSI interactions for research commercialisation and SD in South Africa. The triple helix model (government/science councils, HEIs and the private sector) should be utilised to strengthen the South African NSI. The respondents indicated that research commercialisation (innovations) is produced through interaction in networks and systems of organisations. The findings identified that triple helix relationships include: (i) the institutional landscape; (ii) power relations; (iii) procedures for decision making and coordination; (iv) mechanisms for evaluation and learning, and; (v) the broader contextualising factors such as time, resources, funds, finances, support effort, budgets, responsibilities, performance management culture, among other major drivers and components of the NSI. Financing of HEIs will require monitoring the adequacy of public funding for HEIs and the impacts of the new funding framework, in particular, the funding effects on institutional redress, institutional autonomy, institutional behaviours and enrolment patterns. Training of researchers in areas such as project management, intellectual property, technology transfer and entrepreneurship should be undertaken in order to stimulate research commercialisation within the HEIs. Finally, systemic coherence and a sense of common purpose among the triple helix for the NSI functionality are required. These should include governance, decision-making and funds allocation for research commercialisation and SD.

Research Commercialisation Management

The findings suggest that realising the South Africa TYIP and NGP will require the management of research commercialisation, such as the supply of research capabilities, a strong knowledge base and IP registration. A further argument is that among the NSI actors the government should leverage commercialisation of new innovations for SD.

Sustainable Development Deliverables

Addressing the ‘wicked’ challenges requires a dynamic and responsive NSI institution which is organised to undertake research and research commercialisation for SD. Designing a transition path by the NSI actors will be critical for SD along the economic, social and environmental/ecological dimensions in South Africa, while addressing significant weak points.

Performance and responsibilities: Community Engagement, Teaching and Research

The findings have identified that finalising a policy framework which will facilitate CE on the part of HEIs is required. The core function of HEIs will have to be stretched beyond their traditional boundaries in order to support CE, teaching and research. Academic policy development and implementation will be required to address critical issues and key challenges facing the HEIs.

NSI Communication

The findings indicate that strategic direction is essential for efficient and effective functioning of the NSI. This could be achieved through stronger reciprocal channels of communication to support the NSI institutional arena. A communication plan will have to be part of the integrated policy plan. The development of plans, policies, standards, procedures, objectives, strategy, structure, charts, emails, conference calls and group meetings among the NSI actors will constitute the components of the communications management plan. Table 8.22-1 presents the key NSI communication concepts that can be considered during the policy formulation processes and cycle.

Table 8.22-1: Key concepts proposed for policy communication prepared for this research

CONCEPT	APPLICATION TO THE NSI SYSTEM
Mission	Overriding purpose in line with the values or expectations of key NSI stakeholders. As well as developing the NSI vision and mission statements that will help to define the new process-alignment, roles and responsibilities. Communication must pass one basic test: at minimum; everything must be aligned with vision or mission and must substantially contribute to achieving organisational/institutional objectives.
Vision	Desired future state: the aspiration of the NSI relationships. Communicating the NSI policies vision to all affected stakeholder can be a tremendously important step in the process should entail bringing the prominent NSI stakeholders in line with the NSI vision in order to obtain the desired support.
NSI objectives	Precise statements of purpose or aims. The NSI policy committee should serve the role of translating NSI objectives into action and informing all stakeholders.
Strategies	The way or means in which the NSI objectives will be achieved and put into effect. The NSI communication strategy is an operational strategy which cannot be divorced from main NSI strategy, to which it must contribute if it is to have a genuine role.
Government policy identity, and reputation	Profile and values to be communicated, the set of associations and individual's collective representation of past images of the government (induced through either communication or past experiences) established over time.
Stakeholders	Stakeholder is any group or individual, who can affect or is affected by achievement of the NSI objectives, should be identified and managed accordingly and treated as active rather than passive recipients of policies.
Issue	There several unsettled matters (which are ready for decision) and are a point of conflict between the government and one or more publics and stakeholders.
Communication medium	The tactics and medium that will be used with NSI actors and general stakeholder groups can take many forms such as verbal in-group and individual exchanges of information, and documentation such as drawings, reports, contracts. For example, the policy committee can utilise policy websites, emails, newsletters and review forums to communicate with stakeholders. The inability to communicate critical details can cause policy failure.
Integration	The act of coordinating all communication so that the NSI identity is effectively and consistently communicated to NSI actors and general stakeholder groups. Communication should be used to integrate the NSI policies (SD, research and innovation) and bring the policies to successful implementation.

8.23 SUMMARY

The chapter has in the process provided an overview of pilot testing and questionnaire layout, in terms of results summary and the main questionnaire results and discussion. Furthermore, the chapter has presented the interview results and discussion. In addition, the chapter has discussed the emerging categories from the questionnaire and interview, the emerging cognitive map and framework development. The research methodology and methods assessed the HEIs' research and SD performance, highlighting specific collaborations, strengths and weaknesses and the effectiveness of research commercialisation activities within the NSI. It may be concluded that South Africa's efforts as a whole are insufficient in supporting a transition to the proposed knowledge-intensive economy. However, South Africa has a well-developed base of HEIs, which need to be maintained and strengthened for SD.

CHAPTER NINE

CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

9. CONCLUSION

Chapter Eight analysed and discussed the qualitative and quantitative data of the research. This chapter presents the conclusions and recommendations. This research has examined the South African NSI landscape and linkages with special reference to the role of research commercialisation for SD. The research methodology and methods assessed the HEIs research and SD performance, highlighting specific collaborations, strengths and weaknesses, and the effectiveness of research commercialisation activities, within the NSI. It may be concluded that South Africa's efforts as a whole are insufficient in supporting a transition to the proposed knowledge intensive economy.

South Africa has a well-developed base of HEIs, which need to be maintained and strengthened for SD. This Chapter has identified key requirements for expanding and strengthening the HEIs and overall NSI base to include: development of HCD, provoking the HEIs-private sector research and collaboration efforts, increasing in S&T infrastructure capacity and coordination, increase in resources, capacity and rate of knowledge generation and exploitation and the integration of South Africa's NSI into the African region and global NSI chains.

The recommendation proposes that improving research commercialisation for SD should be high among the triple helix policy agenda. In this regard, the recommendations emphasise the importance of consolidating NSI gains, which should include: efficiency in disseminating research results, efficient exploitation of new knowledge and technology transfer, leveraging the central role of the private sector in the NSI, effective application of IPR, broadening NSI actors' participation and simplification of policies and procedures and efficiency of allocation of funding.

The conclusion have highlighted the key requirements for expanding and strengthening HEIs and the overall NSI base, which include: development of human capital, increase in S&T infrastructure capacity, coordination, M&E of NSI actors, increase in capacity rate of knowledge generation and exploitation and integration and internationalisation of the NSI.

9.1 INTRODUCTION

A number of areas identified in the recommendations that require immediate action include: efficiency in disseminating research results, efficient exploitation of new knowledge and technology transfer, leveraging the role of the private sector in the NSI, effective application of IPR, broadening participation of triple helix actors and simplification of procedures and efficiency in funding allocations. This chapter is organised as follows: section 9.2 provides the conclusions drawn, which reflects a comprehensive set of reforms that have been, and largely remain, necessary in the South African NSI. Section 9.3 outlines a number of recommendations, which cover the identified areas that require immediate action for efficient functioning of the NSI. Sections 9.4 present suggestions for further research.

9.2 CONCLUSIONS

Based on the findings, a number of conclusions have been identified as key requirements for expanding and strengthening HEIs, and overall NSI base.

First, the articulated and persuasive vision of the 1996 White Paper that intends to drive national economic and social development (which should have also included environmental development) has not been adopted widely enough across the range of NSI actors in order to achieve the intended pervasive impact. Similarly, the prospective NSI planning as envisaged in the 1996 White Paper is absent. As a result, the concept of the NSI has continued to be misunderstood and has failed to gain adherents beyond the DST.

Second, South African NSI is characterised by an imbalance in resource allocation. Large-scale national programmes such as the ‘big science’ projects and ‘big technology’ initiatives at the level of the NRF and the DST have obscured other types of innovation critical for innovation for SD within the NSI.

Third, South African NSI lacks an efficient and effective vertical and horizontal coordination, governance and structure, which has a negative effect on the roles and responsibilities of different actors within the system. The coordination measures taken by the government have achieved only limited horizontal and vertical coherence among the various NSI agencies. The argument is that there is a limited capacity by the government to influence national-level strategy and planning for the NSI functioning. The governance and structural challenges have been displayed by a leadership and reporting line vacuum within the NSI. Therefore, NSI governance and structure are insufficient in supporting the proposed knowledge economy and SST. Without a clear policy and policy instruments, the government's strategic plans such as the TYIP, NDP and NGP will continue to be broadly sound, but problematic to implement. In the proposed knowledge transition, growth of the informal and agricultural sectors will also require equal attention as the formal sector. To this end, the required mechanisms for research commercialisation do not exist within the South African NSI.

Fourth, although South Africa's NSI is confronted by grand wicked challenges, which require urgent priorities, addressing SD in the form of social innovation is currently under-conceptualised and under-developed. The findings have identified that policy and research commercialisation domains within the NSI are, to a large extent, disconnected from those dealing with SD issues.

Fifth, South African HEIs have in place some mechanisms for engaging with the private sector. However, this type of engagement represents an emerging role, which is characterised by limited experience and expertise, and resources are needed to strongly drive forward the required collaboration. The exclusion of the private sector from the NSI central policy platform and the persistence of insulated silos mentality within the HEIs and some government agencies have contributed to the weakness of the NSI. The deep-seated gap between industry, government and the HEIs is rooted in a multiplicity of historical, political, philosophical and social factors that require sustained attention to resolve.

Sixth, strengthening the NSI linkages between the HEIs and the private sector is constrained by a lack of research commercialisation skills and low numbers of qualified staff, including doctoral degree holders, brain drain, ageing of faculty due to failure to reproduce the existing researcher cadre, absence of IP policy measures, below-industry-linked staff remuneration and retention, inadequate investment in research infrastructure, failure to incentivise research commercialisation, low student enrolment and poor performance in S&T disciplines, responsibilities associated with lecturing rather than research-focused mandates, interactions between HEIs and private sector being *ad hoc,* piecemeal, local, and opportunistic, as opposed to strategic and proactive and systematic; and the absence of trilateral dialogue among the Science Councils, HEIs and provincial governments.

Seventh, South African NSI is notably fragmented. This is because resources are scattered into different types of institutions with partly overlapping duties – HEIs and public research organisations. The HEIs are also internally fragmented into teaching, CE and with small research units. The fragmented and slow development of productive triple-helix relationships among government, HEIs and the private sector poses a serious problem and a knowledge transfer gap between the actors.

Eighth, a key weakness in the condition of the South African NSI framework is the deficit in the knowledge infrastructure such as HCD flow, both in quantity and nature. Consequently, reforms are required in the schooling and training systems, which have contributed to the consequent shortfall of well-equipped graduates and postgraduates and the production and retention of academics and researchers. Another notable weakness within the NSI is absence of M&E, which is required for ensuring the availability, collation, maintenance, analysis, monitoring and dissemination of NSI performance. Within the African region, the available NSI-related policies are inconsistent and disconnected. The lack of inclusion of the informal sector and the traditional sectors has also produced asymmetrical or ineffective innovation strategies in the region.

Finally, from an international context, the perspective of what it means for South Africa to be internationally competitive within a global knowledge economy is very narrow. International practice of variations, collaboration and linkages are indispensable components of a healthy knowledge transfer and exchange, which can be adapted into the local innovation context. The argument is that being internationally competitive extends to all facets of South Africa requiring high-quality staff, and institutions, policies and regulations that enable, rather than hinder the NSI.

9.3 RECOMMENDATIONS

The following recommendations are aimed at strengthening the South African NSI efficiency, effectiveness and research for SD through the removal of bottlenecks identified in light of the conclusions.

1. **<u>Effective and participatory joint policy-making, planning and coordination at the central policy-making platform are required</u>**

   An effective NSI policy-making platform and governance structure for a responsive South Africa is dependent on a well-defined horizontal and vertical coherence in term of composition and distinctive capabilities. Furthermore, a compelling, visionary and inclusive leadership is required for effective and efficient governance within the NSI. Similarly, a review of the current NSI reporting lines, missions, future functions and resource requirements should be conducted. At the national level, strategy and planning for a truly national and coherent NSI is required. To fulfil its role and responsibility the government and its agencies will have to include appropriate policy development, reprioritised funding, coordinated planning and implementation focused on international collaboration and public-private partnerships.

2. **The triple helix NSI relationship should be formalised**

To be systemic in the fullest sense, the South African NSI will require at least three well-functioning 'core' policy nexuses. The first node will have to centre on the HEIs involving the DHET. The second will have to focus on the productive sector (formal private and informal sectors) involving the DTI, DST and EED. The third node will have to centre on social development and social innovation involving the DST and other relevant departments such as social and rural development, social security, and health and education. Furthermore, well written collaborations and agreements should be formulated spelling out how policy coordination, harmonisation and implementation of action plans will be achieved within and between the policy nexuses.

3. **The central role of private sector in South Africa should be recognised**

Recognising the South Africa's socio-economic realities, in which the NSI operates, is crucial in policy-making, strategy and intervention development. These realities include agriculture, both the formal and informal sectors, which require that the NSI should be steered by a high-level body of experts and functionality mechanisms. In addition, to boost multi-partner, cross-sector collaboration and increase absorptive capacity, the NSI governance should be accompanied by a policy framework that recognises the central role of the private sector as a large-scale funder and performer of research. Effective participation of the private sector in research commercialisation and in addressing complex sustainable (economic, environmental and social) development challenges facing South Africa should be structured through direct and indirect controls into all levels of the NSI. The resulting increased NSI participation of the private sector could promote learning, support of joint funding and projects application or start-up/spin-off joint ventures and mutual sharing. Private sector NSI participation may further be strengthened through improved tax concessions on company grants, scholarships and bursaries deployed in the HEIs.

4. **Government role in research commercialisation for sustainable development should be well-defined**

The role of government within the NSI should include support mechanisms for enhancing HEIs-private sector engagement through policy frameworks. The government should also provide incentives and funds for eliminating constraints and stimulating both demand-pull and supply-push approaches for research uptake and commercialisation. Additionally, the government should develop and implement measures needed to galvanise and integrate policies for research commercialisation and SD.

5. **<u>Strategies to increase research activities and commercialisation within the HEIs should be implemented</u>**

   The proposed strategies should include the development and implementation of fair IP policies and guidelines, human and organisational capabilities at the HEIs and research institutes, strengthening periodic reviewing of NIPMO. The HEIs generally conduct long-term basic research and should equally allocate resources that support practical, solution-oriented research. The mission of HEIs should be transformed by integrating research commercialisation and SD into the research agenda and ensuring the harmonisation of research policy with other HEI policies. A shift from promotion based exclusively on publications towards the inclusion of contributions to entrepreneurial activities and initiatives could improve the participation of academic staff in research commercialisation.

6. **<u>An 'appetite for innovation' should be fostered for transition into the proposed knowledge economy and SST</u>**

   The proposed framework spans a range of NSI relationships. The anticipated components of the framework could be used to inform the work of the government, research, private sector and community of scholars in drawing inferences and providing policy advice, for example in addressing the 'wicked challenges'. A critical element in the NSI framework is the interconnectedness of the agents in the system, linking the common innovation infrastructure to specific clusters. Edquist (1997:18) states that "system of innovation should be looked upon as a 'whole' because many of its elements are – more or less closely – related to each other. Otherwise there would be no 'system'. The transition should entail well-designed, systematic and deliberate executed interventions and governance mechanisms targeting the entire South African NSI. The proposition is that for knowledge transfer between the NSI actors to occur, provision of an enabling environment to bridge the knowledge gulfs should be implemented.

7. **<u>Capacity-building in relevant skills sets should be undertaken</u>**

   An adequate knowledge infrastructure is a crucial condition for a well-functioning NSI. HCD interventions should be put in place as high-level skills shortages have caused a significant constraint in the transition to the proposed knowledge-based economy. Therefore, strategies to strengthen HCD in South Africa should include: increased investment in knowledge infrastructure /skills bases, reformed immigration policies for mobility of skills and an internationally open system. Fostering HEIs-industry linkages by encouraging reciprocal access to equipment, research cluster centres, incubators, technological and industrial parks should also include strategies for strengthening HCD.

8. **M&E instruments and methodologies should be put in place for policy coherence**
   A centralised facility to serve as a repository and distribution for M&E to inform NSI policies and strategies should be set up. A range of M&E instruments and methodologies (data collection, analysis, interpretation and dissemination) should be established for effective NSI steering and functioning. A set of M&E indicators should also be compiled and updated on regular as basis for a fair, transparent and effective system. Therefore, there is an argument to be made for the adoption and implementation of a strong, excellent and thorough reporting system across the various South African NSI schemes.

9. **Increased funding and funding mechanisms is required for the NSI full functionality**
   The government funding for science and research should continue to be applied strategically to strengthen the NSI and stimulate research and research commercialisation. Government funding mechanisms should include: differentiated, priority-setting funding that links performance to research. Government funding should also increase laboratory capacity and scientific infrastructure and equipment, scientific services and programmes such as incubators, design and engineering services, technical services, technology hubs, pilot plants and industrial experiments. Seamless funding arrangements should be put in place within the multi-helix research organisational structure. Finally, funds should also be channelled to uplifting emerging researchers.

10. **Sustainable development structures should be well-defined and supported within the NSI**
    Addressing the grand wicked challenges facing South Africa will require setting up well-defined socio-economic and environmental development and social innovation priorities. The NSI's functionality is core to providing growth, creating jobs and employment, addressing poverty and equity (race and gender) and achieving targets beyond the MDGs goals.

11. **South Africa NSI should serve as an important model and reference point within the African region**
    Among the triple helix actors, measures should be put in place for enhancing research collaboration across the African region and among South–South centres. The proposed

measures include developing and implementing common policy frameworks and investment in advanced national networks and infrastructure. Intergovernmental organisations such as NEPAD will also have to play a critical role in stimulating an active dialogue between the research community, the fragmented African markets and SD initiatives. This is because integration and unity is critical for better use of scarce resources, relative decoupling, enhanced trade regime, undertaking indigenous innovations, collaboration and strengthening of the research and SD community.

12. **From an international perspective, South Africa should serve as an open-system for effective and efficient NSI functioning**

    South Africa should serve as a global open system, with in-flows and outflows of different types of resources and knowledge infrastructure. The open NSI should include fair immigration policies to attract skills, expertise, networking facilities and cyber-infrastructure for advanced communication. The internationally receptive South African NSI should also serve as a powerful repository for exchange and collaboration for promoting, disseminating and commercialisation of research, including identifying superior technologies and good practice for adaptation into local contexts. International NSI trends to be adopted should include collaborative programmes with international research agencies, scientific projects, international cooperation and resources and adoption of knowledge-and cyber-infrastructure (human resources, equipment and facilities, and infrastructure) within the public sector.

9.4 SUGGESTIONS FOR FURTHER RESEARCH

Owing to the dearth of research within the NSI literature, further research should seek to explore the demand for the various types of government led innovations in order to determine their appropriateness. Further research could expand and explore the value of and the return on research investments within the NSI. Furthermore, research should be conducted to examine the various layers of NSI interactions, the depth of these various levels and the kind of crossovers that occur. Further investigation on the factors and HEIs characteristics that have enabled some of them to commercialise research and establish financially-productive relationships with the private sector can provide useful insight for NSI functionality.

10. APPENDICES

APPENDIX 1

UNIVERSITY OF
KWAZULU-NATAL

5 March 2014

Dear

PHD STUDENT: MS WANJIRU GACHIE (REG NO 202526216
TOPIC OF RESEARCH: SUSTAINABLE DEVELOPMENT IN SOUTH AFRICA THROUGH RESEARCH IN THE NATIONAL SYSTEM OF INNOVATION

We write to you in our capacity as Research Supervisors to the above Student.

We understand that Ms Gachie has been experiencing some challenges in collecting data from your institution although consent has already been granted. As a researcher you would appreciate the significance of collecting data in advancing research. Also, you would be aware that Universities in South Africa and elsewhere are placing great emphasis on PhDs. For these reasons as research supervisors we would be highly indebted to you if you would spend 30 minutes of your valuable time in completing the attached questionnaire.

Thank you for your time.

Yours sincerely

PROFESSOR Y PENCELIAH
SUPERVISOR
SENIOR RESEARCH ASSOCIATE : PUBLIC GOVERNANCE
SCHOOL OF MANAGEMENT, IT AND GOVERNANCE

DR MO DASSAH
CO-SUPERVISOR
ACADEMIC LEADER: PUBLIC GOVERNANCE
SCHOOL OF MANAGEMENT, IT AND GOVERNANCE

APPENDIX 2:

Country statistical profiles: Key tables from OECD - ISSN 2075-2288 - © OECD, 2013b									
Country statistical profile: South Africa 2013									
	Unit	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Production and income									
GDP per capita	USD current PPPs	8 000	8 654	9 336	10 049	10 453	10 238	10 498	..
Gross national income (GNI) per capita	USD current PPPs	7 820	8 429	9 079	9 599	10 065	10 006	10 322	10 743
Household disposable income	Annual growth %	5.8	5.0	6.9	5.2	0.3	1.8	5.8	..
Economic growth									
Real GDP growth	Annual growth %	4.6	5.3	5.6	5.6	3.6	-1.7	2.8	..
Net saving rate in household disposable income	%	0.4	0.1	-0.8	-1.2	-1.1	-0.7	-0.3	-0.1
Gross fixed capital formation	% of GDP	12.9	11.0	12.1	14.0	14.1	-2.2	-3.7	..
Trade									
Imports of goods and services	% of GDP	26.7	27.9	32.5	34.2	38.6	28.3	27.5	..
Exports of goods and services	% of GDP	26.4	27.4	30.0	31.5	35.6	27.4	27.3	..
Goods trade balance: exports minus imports of goods	Bln USD	-7.3	-8.0	-15.9	-15.8	-13.6	-9.9	-8.7	-6.8
Imports of goods	Bln USD	47.6	55.0	68.5	79.9	87.6	63.8	80.1	99.7
Exports of goods	Bln USD	40.3	47.0	52.6	64.0	74.0	53.9	71.5	93.0
Foreign direct investment (FDI)									
Outward FDI stocks	Mln USD	..	..	..	..	..	72 583	89 453	..
Inward FDI stocks	Mln USD	..	..	..	..	..	117 434	153 133	..
Inflows of foreign direct investment	Mln USD	..	..	6 063	2 966	-3 134	1 151	-76	-635
Outflows of foreign direct investment	Mln USD	..	..	-527	5 695	9 007	5 696	1 228	5 807
Prices and interest rates									
Inflation rate: all items	Annual growth %	-0.7	2.1	3.2	6.2	10.1	7.2	4.1	5.0
Inflation rate: all items non-food non energy	Annual growth %	-1.6	1.7	2.3	5.2	7.8	7.4	4.0	3.5
Inflation rate: food	Annual growth %	1.4	1.7	6.0	10.0	15.5	9.4	1.2	7.1
Inflation rate: energy	Annual growth %	8.4	10.6	9.3	8.6	26.8	-2.5	15.4	18.9
Producer Price Indices (PPI): manufacturing	Annual growth %	2.0	3.7	6.4	9.8	15.2	0.7	1.9	5.7
Long-term interest rates	%	9.53	8.07	7.94	7.99	9.10	8.70	8.62	8.52
Purchasing power/exchange rates									
Purchasing power parities	ZAR per USD	3.81	3.87	4.00	4.19	4.47	4.75	4.99	..
Exchange rates	ZAR per USD	6.46	6.36	6.77	7.05	8.26	8.47	7.32	7.26
Indices of price levels	OECD = 100	58	60	59	58	51	55	67	69
Energy supply and prices									
Total primary energy supply (TPES)	Mtoe	128.7	128.2	127.2	137.3	147.7	144.3	136.9	..
TPES per unit of GDP at 2000 prices and PPPs	Toe per '000 USD	0.33	0.32	0.30	0.30	0.32	0.31	0.29	..
Renewables' contribution to total primary energy supply	%	10.5	10.7	11.0	10.2	9.6	9.9	10.7	..

Information and Communications Technology									
Households with access to Internet	%	..	3.0	..	..	..	..	10.1	9.8
Environment									
Municipal waste total	'000 tonnes	..	1 370	..	..	..	..	..	..
Municipal waste per capita	Kg	..	..	..	..	..	..	..	..
CO_2 emissions from fuel combustion	Mln tonnes	336	329	330	355	387	369	347	..
Education									
Tertiary attainment in population aged 25-64	%	..	..	..	..	..	..	..	..
Expenditure per student: non-tertiary, 2009 prices	USD constant PPPs	..	..	..	..	..	1 697	..	..
Expenditure per student: tertiary, 2009 prices	USD constant PPPs	..	..	..	..	..	3 616	..	..
Employment									
Employment rate in population aged 15-24	%	13.8	15.0	16.0	15.7	16.5	14.4	12.8	12.7
Employment rate in population aged 25-54	%	57.4	59.3	61.1	60.6	60.9	58.7	56.6	56.5
Employment rate in population aged 55-64	%	39.6	42.2	43.6	42.2	40.9	39.2	37.3	38.0
Incidence of part-time employment	%	7.5	8.4	9.1	8.0	8.2	8.3	8.1	7.7
Unemployment									
Unemployment rate: total labour force	%	23.0	23.5	22.1	21.0	22.9	23.9	24.9	24.9
Unemployment rate, men: male labour force	%	19.9	19.7	17.8	18.2	20.0	22.1	22.8	22.4
Unemployment rate, women: female labour force	%	26.6	27.8	27.0	24.3	26.3	26.1	27.5	27.9
Long-term unemployment: total unemployed	%	65.1	63.7	59.5	57.7	49.5	49.3	56.1	58.8
Research and Development (R&D)									
Gross domestic expenditure R&D	Mln USD	3 271	3 654	4 005	4 179	4 335	..	..	..
Researchers: full-time equivalent	Per '000 employed	1.5	1.4	1.5	1.5	1.4	..	..	..
International migration									
Foreign-born population	% of population	..	2.6	..	..	..	..	3.7	..
Unemployment rate of native-born men	% of labour force	..	..	..	25.3	..	..	..	..
Unemployment rate of foreign-born men	% of labour force	..	..	..	11.3	..	..	..	..
Unemployment rate of native-born women	% of labour force	..	..	..	31.4	..	..	..	..
Unemployment rate of foreign-born women	% of labour force	..	..	..	25.0	..	..	..	..
Health									
Life expectancy at birth	Years	51.5	51.1	51.0	51.0	51.3	51.6	52.1	..
Life expectancy at birth: men	Years	49.9	49.7	49.7	50.0	50.3	50.8	51.4	..
Life expectancy at birth: women	Years	53.1	52.5	52.2	52.1	52.2	52.4	52.8	..
Infant mortality	Per '000	54.0	52.9	49.2	47.3	45.0	42.5	40.7	..
Overweight and obese aged over 15	% of population	..	..	..	..	..	..	42.4	..
Suicide rates	Per 100000persons	0.4	0.5	0.5	0.5	0.4	0.4	..	..
Last updated: 28 February 2013; disclaimer: http://oe.cd/disclaimer									
Source: OECD Fact book statistics. For explanatory notes, see OECD Fact book 2013 (DOI: 10.1787/factbook-2013-en)									

APPENDIX 3:

FINAL QUESTIONNAIRE (NO CODING)

Informed Consent Letter 3C

UNIVERSITY OF KWAZULU-NATAL
SCHOOL OF SCHOOL MANAGEMENT, IT AND GOVERNANCE LEADERSHIP

Dear Respondent,

DA Research Project
Researcher: Wanjiru Gachie (0729212899)
Supervisor: Prof. Yogi Penceliah (031 260 7645)
Co-Supervisor: Dr. Maurice Dassah (031 260 7673)
Research Office: Ms. P Ximba (031-2603587)

I, Wanjiru Gachie, I am a Doctor of Administration student, at the School Management, IT and Governance at the University of KwaZulu-Natal (UKZN). In conjunction with my research supervisors I invite you to participate in a research project entitled Sustainable development in South Africa through research in the national system of innovation. The aim of this research is to: examine the role of research in the National System of Innovation (NSI) in creating sustainable development in South Africa.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/interview. Confidentiality and anonymity of records identifying you as a participant will be maintained by the School Management, IT and Governance, UKZN.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor at the numbers listed above.
I hereby request for you to complete consent form and email to researcher (gachiee@ukzn.ac.za).

Sincerely

Investigator's signature Date : 16/04/2014

QUESTIONNAIRE
1. BACKGROUND ABOUT THE INSTITUTION

i) Name:---
ii) Main activity:---
iii) Brief research historical background:--

2. RESEARCH AND SUSTAINABLE DEVELOPMENT ROLE

i) How does your institution contribute to sustainable development in South Africa in terms of the three pillars namely (economic, environmental or social role)?

ii) Does your institution have in place policy documents that apply specifically to research and sustainable development? If yes, what is the one main objective of each?

iii) What are the main challenges facing your institution with respect to the above policies?

3. MEASURING EFFECTIVENESS OF RESEARCH COMMERCIALISATION

i) Has your institution played a role in commercialisation of research in the last five years?

ii) What roles could be foreseen for Higher Education Institutions (HEIs) research for the private sector?

iii) What current barriers/challenges need be overcome in the HEIs research assisting the private sector?

iv) From your research perspective, identify any three factors that can lead to successful research commercialisation in your institution.

v) What role has your institution's intellectual property (IP) rights office played in research?

vi) From your institutional perspective, what kind of policies should be pursued to improve the research and research commercialisation of South African HEIs?

4. NATIONAL SYSTEM OF INNOVATION ACTORS

i) From your institutional perspective what should be the nature of the relationship between HEIs and business and government? (The main NSI actors include the government, private sector and HEIs).

ii) From your institutional perspective, describe the main weaknesses of the above relationship.

iii) What do you suppose should be done by the government, business/private sector and HEIs to strengthen the above relationship?

5. GOVERNMENT SUPPORT, FUNDING AND INCENTIVES

i) Describe the major sources of research funding in your institutions.

ii) In which ways can the government support your institution in facilitating research commercialisation?

APPENDIX 4:

Informed Consent Letter 3C

UNIVERSITY OF KWAZULU-NATAL
SCHOOL OF SCHOOL MANAGEMENT, IT AND GOVERNANCE LEADERSHIP

Dear Respondent,

DA Research Project
Researcher: Wanjiru Gachie (0825978578)
Supervisor: Prof. Yogi Penceliah (031 260 7673)
Co-Supervisor: Dr. Maurice Dassah (031 260 7673)
Research Office: Ms. P Ximba (031-2603587)

I, Wanjiru Gachie, I am a Doctor of Administration student, at the School Management, IT and Governance at the University of KwaZulu-Natal (UKZN). In conjunction with my research supervisors I invite you to participate in a research project entitled Sustainable development in South Africa through research in the national system of innovation. The aim of this research is to: examine the role of research in the National System of Innovation (NSI) in creating sustainable development in South Africa.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/interview. Confidentiality and anonymity of records identifying you as a participant will be maintained by the School Management, IT and Governance, UKZN.

If you have any questions or concerns about completing the interview questions or about participating in this study, you may contact me or my supervisor at the numbers listed above.
I hereby request for you to complete consent form and email to researcher (gachiee@ukzn.ac.za).

Sincerely,

____
Investigator's signature Date : 16/09/2014

Areas research commercialisation, community engagement and sustainable development at your institution

1. Which are most common types of community engagement activities conducted in your institution?
2. Which are most commonly reported collaborations with the regard to private sector?
3. What are some of the benefits (tangible and intangible) for engaging with the private sector in terms of research commercialisation, community engagement and sustainable development at your institution?
4. In general, how has your institution optimised its research vision in terms of sustainable development and commercialisation of research?
5. What are some of the factors account for resistance to or lack of responsiveness to sustainable development and commercialisation of research?
6. What are some of the challenges/weaknesses facing your institution within the NSI?
7. What are some of the areas of policy solutions/suggestions for government in support the HEIs contribution to sustainable development and research commercialisation?
8. What are some of the areas of policy solutions/suggestions for the HEIs for sustainable development, community engagement and research commercialisation?
9. What "next steps" have you planned at your HEIs to strengthen commitment to sustainable development, community engagement and research commercialisation?
10. Please add any additional comments.

APPENDIX 5:

Ethical clearance approval

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

10 January 2014

Ms Wanjiru Gachie (202526216)
School of Management, IT and Governance
Westville Campus

Protocol reference number: HSS/0656/013D
Project title: Sustainable development in South Africa through research in the National System of Innovation

Dear Ms Gachie

Full Approval – Expedited

In response to your application dated June 2013, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

Please note: Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....
Dr Shenuka Singh (Chair)

/ms

cc Supervisor: Professor Yogi Penceliah and Dr Maurice Oscar Dassah
cc Academic Leader Research: Professor B McArthur
cc School Administrator: Ms A Pearce

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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