SCIENCE AND TECHNOLOGY POLICIES AND STRUCTURES IN SOUTHERN AFRICA: A DISCUSSION OF THE CONCEPT OF NATIONAL SYSTEM OF INNOVATION WITH REFERENCE TO MALAWI, NAMIBIA AND SOUTH AFRICA.

RETHABILE OLIVE MALUKE

Assignment presented in partial fulfilment of the requirements for the degree of Master of Philosophy at the University of Stellenbosch

Supervisor: Prof. Johann Mouton

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DECLARATION

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously submitted it at any university for a degree in its entirety or in part.

Signature: Date: 3 March 2004

ABSTRACT

The interface between science and technology and the society has led to the notion of science as a social contract, in which scientists, politicians and the general public are called upon to acknowledge the urgency of using all fields of science and technology to address human needs. Science and technology is used as an instrument of change for a better quality of life and sustainable development for the present and future generations. The object of science and technology policies is to achieve specific development objectives. It is thus imperative to adopt science and technology policies that support the national development strategies. It is also important to set up science and technology structures to facilitate the proper functioning of the science and technology system.

Competitiveness constitutes one of the most important challenges facing Southern Africa today. With globalization and the expansion of world trade competition, it has become more difficult for Southern African enterprise to keep up with the pace of technological developments. In the light of these challenges, most countries are driving towards the adoption of a national system of innovation (NSI) to encourage the interaction of policies, research and development, human resource development and industrial development.

The study is induced by major science and technology set backs, which are common across countries in Southern Africa namely, poor co-ordination mechanisms, poor science and technology infrastructure and a lack of funding.

The study provides background information on the theoretical framework of the concept of NSI. For the research method, a qualitative research design was followed with content analysis of existing documents. Published documents were used to provide information on the three countries, which were used as case studies namely Malawi, Namibia and South Africa. The main focus of the case studies is on the following: an outline of the policy goals of each of the three countries, the concept of the NSI as it is expressed by each of the countries and the science and technology structures in the three countries.

The study identified poor co-ordination of science and technology activities as the key problem of all three countries. The structures differ slightly and in particular, the placement of the management of science and technology determines the efficiency of the system. The South

African NSI is well established as its network is strengthened by the National Advisory Council for Innovation and the National Research and Development Strategy. Next is Namibia which has a system in place, while Malawi is still at the initial stages of setting up its NSI.

OPSOMMING

Die koppelvlak tussen wetenskap en tegnologie en die gemeenskap het gelei tot die siening van wetenskap as 'n sosiale kontrak waarin wetenskaplikes, politici en die algemene publiek versoek word om te erken dat dit nodig geword het om alle vertakkinge van wetenskap en tegnologie aan te wend om menslike nood te verlig. Wetenskap en tegnologie word gebruik as 'n instrument om verandering teweeg te bring ter bevordering van 'n beter kwaliteit lewe en volhoubare ontwikkeling vir die huidige en toekomstige generasies. Die doel van 'n wetenskap en tegnologiebeleid is om spesifieke ontwikkelingsdoelstellings te verwesenlik. Dit is dus noodsaaklik dat hierdie beleid in ooreenstemming met die nasionale onwikkelingsstrategieë ontwerp moet word. Dit is ook belangrik om wetenskap en tegnologiestrukture in plek te stel wat die effektiewe funksionering van die sisteem kan vergemaklik.

Mededingbaarheid is een van die grootste uitdagings wat Suider Afrika tans in die gesig staar. Met globalisering en die uitbreiding van wêreldhandel het dit moeiliker geword vir Suider Afrikaanse ondernemings om in pas te bly met tegnologiese ontwikkeling. In die lig van hierdie uitdagings stuur die meeste lande in die rigting van 'n Nasionale Sisteem vir Innovasie (NSI) om interaksie tussen beleid, navorsing en ontwikkeling , menslike hulpbronontwikkeling en industriële ontwikkeling aan te moedig.

Wat aanleiding gegee het tot hierdie studie is die wetenskap en tegnologieprobleme wat algemeen voorkom in die lande in Suider Afrikaanse, naamlik onvoldoende koördinasie meganismes, swak wetenskap en tegnologie-infrastruktuur en 'n gebrek aan fondse.

'n Kwalitatiewe navorsingsontwerp is gevolg waarin analise van die inhoud van dokumente as navorsingsmetode gebruik is. Die studie verskaf agtergrond-inligting oor die teoretiese raamwerk van die NSI konsep. Gepubliseerde dokumente is gebruik om inligting te verskaf oor die drie lande wat as gevallestudies dien, naamlik Malawi, Namibië en Suid-Afrika. Die hooffokus van die gevallestudies is soos volg: 'n raamwerk van die beleidsdoelstellings van elk van die drie lande, die konsep NSI soos toegepas deur elkeen en die wetenskap en tegnologiestrukture in elk van die betrokke lande.

Die studie het swak koördinasie van wetenskap en tegnologie-aktiwiteite as die sleutelprobleem van aldrie lande geïdentifiseer. Die strukture verskil effens van mekaar en veral die plasing van

die wetenskap en tegnologiebestuur bepaal die effektiwiteit van die stelsel. Die Suid Afrikaanse NSI is goed gevestig omdat sy netwerk versterk word deur die Nasionale Adviesraad vir Innovasie en die Nasionale Navorsing- en Ontwikkelingstrategie. Volgende is Namibië wat 'n sisteem in plek het, terwyl Malawi nog maar in die beginstadium is van die daarstelling van hul NSI.

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Last but not least, may I give my honour and praise to my loving God. I declare his unconditional love through his words in Psalm 37: 3-4

> *"Trust in the Lord and do good; live in the land and be safe. Seek your happiness in the Lord, and he will give you your heart's desire. Give yourself to the Lord; trust in him and he will help you."*

This was my anchor throughout the process of my thesis.

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List of acronyms and abbreviations

AASTOM	Association for the Advancement of Science and Technology of Malawi
ACST	Arts, Culture, Science and Technology
ANC	African National Congress
ASC	Agricultural Sciences Committee
BEE	Black Economic Empowerment
CASTAFRICA	Conference of Cabinet Ministers responsible for the applications of Science and Technology in Africa.
CHSC	Committee of Heads of Science Councils
CHSU	Community Health Services Unit
CISR	Council for Scientific and Industrial Research Coordinating Committee
CRII	Council for Science and Industrial Innovations
CSIRD	Committee for Scientific and Industrial Research and Development
CSTE	Council for Science and Technical Education
CTP	Committee of Technikon Principals
CUP	Council of University Principals
CVIT	Council for Vocational and Industrial Training
DACST	Department of Arts, Culture, Science, and Technology
DARTS	Department of Agricultural Research and Technical Services Development
FIST	Fund for Innovation in Science and Technology
FRST	Foundation of Research Science and Technology
FTI	Foundation for Technological Innovation
GDP	Gross Domestic Product
GDS	Growth Development Strategy
GRBC	Genetics Resources and Biotechnology Committee
HRD	Human Resource Development
HSRC	Human Sciences Research Council
IDRC	International Development Research Centre
LPPC	Legal and Patenting Policies Committee
MBS	Malawi Bureau of Standards
MCST	Ministers Council for Science and Technology

MHEVTST	Ministry of Higher Education, Vocational Training, Science and Technology
MIRTDC	Malawi Industrial Research and Technology Development Centre
MNCs	Multinational companies
NACI	National Advisory council on Innovation
NADICC	National Documentation and Information
NCRST	National Council of Research Science and Technology
NGO	Non Governmental Organisations
NHBGM	National Herbarium and Botanic Gardens of Malawi
NCST	National Commission for Science and Technology
NCRST	National Commission for Research, Science and Technology
NIC	Newly Industrialised countries
NRCM	National Research Council of Malawi
NRF	National Research Foundation
NSI	National System of Innovation
NSTF	National Science and Technology Fund
R & D	Research and Development
RDP	Reconstruction and Development Programme
S & T	Science and Technology
SAC	Scientific Advisory Council
SADC	Southern African Development Community
SCC	Science Competitions Committee
SET	Science Engineering and Technology
SPII	Support Programme for Industrial Innovation
STIC	Science and Technology Information Centre
UCT	University of Cape Town
UNESCO	United Nations Education Scientific and Cultural Organisation
UP	University of Pretoria
US	University of Stellenbosch

Chapter 1. Research Design

1.1 Introduction

The recognition of science[1] and technology[2] (S&T) as major tools for development do not only form the headlines in this era of the information age, but are built in as critical instruments in the blueprint of a nation for its economic progress. Today, more than ever, the natural and social sciences and their applications are indispensable to development.

The importance of science and technology as the engines of growth and development cannot be over emphasized. Science and technology has always formed an integral part of societal well-being since the beginnings of economic activities. In the current era of globalisation, Science and Technology continue to be recognized as the most decisive factors in determining differences in the ways in which progress in economic development, especially among the Newly Industrializing Countries (NICS), is achieved.

Governments of the developing world have placed science and technology high on their developmental programs. This is witnessed through the establishment of science and technology management institutions, and the bilateral, international, regional protocols and agreements on science and technology. The unlimited horizon of science and technology is expressed by scientific and technological innovations. These innovations make science and technology even more interesting and have afforded many countries the possibilities to venture into different ways of scientific and technological advances. For example, Japan is well known as a leading country in electronics, while India is known for its best practices in appropriate agro technologies.

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1 *Science* is commonly limited to the natural sciences such as chemistry and physics. *Science* in this paper is used in a generic way, that is, it is considered 'a body of knowledge created through formal processes of research. The emphasis is on scientific method which is an exact and systematic way of understanding the world' (South Africa's Green Paper on Science and Technology, January 1994). *Science* refers to the sum of the knowledge of facts, natural laws, and phenomena that have been verified through observation, experimentation and logical thought (J.S. Wessels, 1988). *Science* can also be defined as a system of knowledge that can serve as a theoretical basis for the development of practical techniques, or technology (Loxton 1992:135 in Wessels).

2 Don Ihde (1983) indicates that the term *technology* is derived from a Greek word *techne* which means the activities and skills of a craftsman and for the arts of both mind and hands buts also linked to creative making. *Technology* is the mode of revealing, that is, the essence of technology allows us to see, to order and to relate to the world in a particular way.

The Southern African countries, taking note of the undisputed contributions of science and technology in socio-economic growth and development, realised the need to establish science and technology agencies/institutions. The mandates and programmes of these institutions range from the acceleration of human capacity development in Science and Technology to the provision of technical assistance on science and technology, the promotion and administration of science and technology, research and development (R&D), the facilitation of the acquisition, adaptation, adoption and transfer of technology initiation, the formulation, monitoring of national science and technology policies and the co-ordination and inter-governmental co-operation on science and technology matters.

All these important functions of the science and technology institutions need functional science and technology structures designed to facilitate the implementation and execution of these mandates.

1.2 Rationale

In spite of the efforts made by most developing countries to establish science and technology management institutions, science and technology development progress continues to be very slow hence most countries still remain a long way from scientific and technological modernity. This is the case even in the Southern African countries where the focus of the study is. The odds against the development of science and technology in most Southern African countries revolve around problems such as weakness of the domestic economy, the limits of technology transfer and acquisition efforts, and the poor Science and Technology coordination mechanisms. Most countries still rely heavily on agriculture and primary commodities to generate development revenue; hence, a lack of access to and command over technology has made it difficult for these countries to compete in the global market. Competitiveness now derives from the possession of technological knowledge, the effective application of which should result in improved machinery, new products, cost reduction and productivity improvements. The importation of necessary tools and human skills by the multinational companies (MNCs) has not translated into any real transfer of technology. The situation is such that most African countries have not reached technological advancement, and as a result most Southern African countries are not only locked into a technological lag, but they are unable to cope with the increasing gap between themselves and the rest of the technological world.

Given the acknowledged centrality of science and technology to these nations' socio-economic development, research is thus needed to provide long-term strategic support to decision makers to ensure rapid development of the sector. This is why I undertook a descriptive study of science and technology systems in three Southern African countries, namely Malawi, Namibia, and the Republic of South Africa. However, there is also a need for a study that provides very broad access to the science and technology management styles within the National System of Innovation (NSI), so as to enable rapid diffusion, adaptation and assimilation of technologies in the production structures of Southern African countries. As the Brandt Commission (1980) indicated, "…a country will only be able to benefit from additional technology if it can absorb and adapt what it has already received, and if it can provide the welcoming structure which can connect up new technology to old societies".

It is evident from all indications given above that empirical research into the institutional structures designed to implement the science and technology mandates is necessary. Most of the research currently undertaken by science and technology institutions focuses on science and technology human resource development, information technology, biotechnology, new materials, technology surveys and so on. Very little reference is being made to the structural arrangements within science and technology institutions, "yet technological capability is not a single item but one comprising knowledge, skills, experience and institutional structures and linkages" (Oyelaran-Oyeyinka, 1998). Moreover, although baseline studies intended for the development of national science and technology policies have been undertaken, studies on Science and Technology development capable of leading to harmonious situational policy implementation, especially during the new era of regional integration and economic globalisation, have not been seriously considered.

1.3 Objectives of the study

Recognizing the existing gaps in the general science and technology research priorities, this study is aimed at achieving the following objectives:

- To undertake a descriptive study of science and technology policy and structures in Southern Africa, with reference to three countries, namely Malawi, Namibia and South Africa.
- To discuss the concept of NSI with reference to Malawi, Namibia and South Africa.

The hypothesis of this study can be formulated as follows: "*most of Southern African countries engage in a national system of innovation in their science and technology management in order to achieve economic competitiveness*". The study follows an inductive approach in which a detailed study of how the science and technology systems operate in the three countries will be made, and from the examination of the official documents to be used, one will then reach conclusions.

1.4 Methodology

The quantitative paradigm (also referred to as the naturalistic view) emphasizes the objectivity[3] and reliability[4] of the research results. The qualitative paradigm (the ontological view) on the other hand, embraces the interpretative[5] approach. What is important to the interpretative social scientist is how people understand their worlds and how they create and share meanings about their lives (Rubin & Rubin 1995).

Considering the research problem at hand may shed light on the debate, that is, whether the research design has to follow a quantitative or qualitative approach depends on what the research questions seek to address. As Thomas D. Cook and Charles S. Reichardt (1979) reckons,

> "It is time to stop building walls between the methods and start building bridges. Perhaps it is even time to go beyond the dialectic language of qualitative and quantitative methods. The real problem is to fit the research methods to the problem without parochialism."

This statement calls for a combination of qualitative and quantitative methods. (Mouton 1996) advocates and gives an example of the case where the researcher uses probability-sampling techniques in conjunction with in-depth interviewing or basic descriptive statistics in analysing qualitative data. He argues that it is "...actually one of the best ways to improve the quality of research".

One may also concur with Glaser and Strauss (1967, in Thomas D. Cook et. al. 1985) where they acknowledge, "...there is no fundamental clash between the purposes and capacities of

3 Positivists argue for a value-free science that is objective, that is, the observers agree on what they see and that science is not based on values, opinions, attitudes or beliefs (Derksen & Gartrell, 1992 in W.L. Neuman 1997:66).
4 The observed must be replicated or reproduced, therefore, two conditions have to be satisfied that is, explanations must have no logical contradictions and they must be consistent with observed facts (W.L. Neuman 1997).
5 The systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds (W.L. Neuman 1997:68).

qualitative and quantitative methods or data … We believe that *each form of data is useful for both verification and generation of theory, whatever the primary of emphasis"* (emphasis). These methods can therefore, be used complementarily in the pursuit of knowledge creation.

Qualitative research is largely associated with interactions between the researcher and the subjects. This is why it is often criticised for being more subjective[6] than objective in nature because human beings are dynamic social beings. The other form of qualitative which can also employed by the interpretative paradigm is the non-reactive/unobtrusive[7]. There are basically two types of unobtrusive measures, these are 'erosion' and 'accretion' measures Neuman (1997). Webb et. al in Babbie et. al (2001) classifies unobtrusive measures in terms of 'passive' classification of data. He holds a similar meaning to the one indicated by Neuman (1997) whereby they imply passive/erosion to mean physical traces. Babbie (2001) provides the other classification, which is based on methods of acquiring data. He elaborates on three categories of unobtrusive measures namely 'captured data', 'found data' and 'retrieved data.' For the purpose of the study, I will only focus on the retrieved data as the method to be followed in this thesis.

Data collection relies on the running records[8] whereby an analysis of existing documents in the form of government records from which the descriptions of the science and technology structures in three countries are undertaken. The use of existing documents is appropriate when a researcher wants to test hypotheses involving variables that are also in official reports of social, economic and political conditions. These include descriptions of organizations or people in them (Lawrence 1997).

Purposive sampling[9] was preferred in this study because there were known contact persons who could provide the information needed for the study. Access to information posed the main limitation to the scope of the study.

6 Subjective is often meant to imply "influenced by human judgement" (Thomas D. Cook et al. (Eds) 1985:12).
7 Unobtrusive measures refer to data gathered by means that do not involve the direct acquisition of information from research subjects (Babbie et. al. 2001).
8 The ongoing continuing records of a society (Babbie et. al. 2001)
9 Purposive sampling is a non-probability sampling method that is normally used when data is found from specific sources such as informants.

1.5 The main argument

In order to facilitate a well-coordinated science and technology system, most countries are driving towards what is called a national system of innovation to allow an appreciation of the current interaction among policies, programmes and organisations within the state and to permit the elaboration of practical steps that might be taken to improve the ways in which science and technology are used to promote economic and social development. As put in the OECD Report 1991, "The interactive character of the innovation process calls for organizational[10] structures and mechanisms to ensure appropriate interactions and feedback inside corporations as well as among various institutions that make up the national systems of innovation. For both analysis and policy, this model underscores the importance of cooperation between firms and institutions[11], and thus, the role played by major changes in the area of innovation". Edquist C. (1997) further indicates that the interaction between the organisations concerns the exchange of information and knowledge while the relations between organisations and institutions are essential for innovations and for the systems of innovation. These statements emphasize the importance of knowledge sharing between and among the organisations and institutions as a critical element of the NSI.

Science policies[12] fall within a broad framework of public policy[13], and can be regarded as implementation instruments for government/public policy. Science policy refers to the collective measures taken by a government in order, on the one hand, to encourage the development of scientific and technical research and, on the one the other, to exploit the results of this research for general political objectives (Derek de Solla Price et al., 1977). The reconciliation of science and societal needs leads to an area of Research and Development through contributions from science and technology (Loxton, 1992).

Science and technology needs an enabling environment for its proper functioning. This would include planning the development of a national system and infrastructure for the effective generation of R&D knowledge, determining national R&D priorities and monitoring of the

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[10] Organisations are formal structures with an explicit purpose and they are consciously created (Edquist C. 1997).
[11] Institutions are sets of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organisations (Edquist C. 1997).
[12] Science policies can be seen as the enabling instruments used by the government to harmonize the logic of science with the needs of society (Garber 1992 in Loxton 1992).
[13] Public Policy refers to a declaration of intent, a specification of objectives and a broad description of different vais in which particular objectives will be pursued.(J.S Wessels in Steyn 1971).

system (Loxton, 1992). J.S Wessels (1992) outlines the functional areas, which the government can undertake for the advancement of science and technology:

- Policy formulation and direction
- The generation, exchange and utilization of knowledge
- The provision of an adequate infrastructure
- Coordination and cooperation.

The main thrust of the thesis centres on the functional issues mentioned above.

1.6 Outline

Having looked at the research design and the main argument of this thesis, the outline will now be presented. The study is premised on three main issues: firstly, the thesis discusses the main elements of science and technology policy and the theoretical and conceptual framework of a national system of innovation. Secondly, the thesis provides the case studies of three countries, namely Malawi, Namibia and the Republic of South Africa. It focuses on the ways in which the three countries express their science and technology policy goals and how they have embarked upon the NSI. Thirdly, the thesis describes the structural arrangements and further illustrates how the science and technology mechanisms articulate their NSIs within their structures. Fourthly, and lastly, the main conclusions and recommendations are presented.

Chapter 2 Science and Technology policy

2.1 Science and Technology policy

This section begins with a short description of science and technology policy, followed by an outline of the main elements of science and technology policies. Science and technology policy is concerned with the generation, acquisition and application of knowledge from all of the sciences (social as well as natural) by countries in pursuit of their own economic, social and cultural development. It encompasses all aspects of the support for research. Science and technology policy is vitally concerned with the links that should exist between research and those institutions – both public and private - that make use of the knowledge and technologies emerging from the global science and technology system. Science and technology policy also involves the various activities of public and private bodies to design and stimulate technical change and innovation, all of which are directly linked to research (IDRC, 1993). Shils (1968: ix, in Marais, 2000) views science and technology policy as the 'deliberate effort to influence the direction and rate of the development of scientific knowledge through the application of financial resources, administrative devices, and education and training in so far as these are affected by political authority.

The IDRC definition incorporates the main elements of NSI definition and hence provides a holistic definition of the science and technology policy. The main thrust of science and technology policy is based on knowledge creation and applications of such knowledge for socio-economic development.

What provokes the development of science and technology policy? We are all aware of the fact that social activities do not just occur in a vacuum but they are influenced by the social context within which societies operate. Marais (2000) outlines some of the factors that contribute to the development of S&T policy and systems. These are:

- The socio-geographical environment
- Political history
- The role of ideology
- The role of a country's constitutional system
- Economic development
- Vision of science
- S&T potential and capacity

- International trends.

The above list emphasizes the importance of S&T development to social needs as it includes all the elements of society i.e. politics, economy, and culture.

Having described the science and technology policy, the question is, how are the science and technology policies used. Some authors, Hamel (1999), Garbers (1996) and Marais (2000) indicate functions of science and technology policy these include;

- Incorporation of S&T in government policy and specification of relationship between different government sectors.
- The identification and promotion of specific S&T priorities that are deemed to be of strategic importance.

The IDRC (1993) provides a summary of the functions of a national science and technology policy see page 12.

Table 1. Functions of Science and Technology

Policy and Regulatory functions	Executing Mechanisms
Mechanism(s) 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 assessing the likely directions of technical change	Institutions to execute research programmes
Capacities to regulate complex technological activities	Mechanisms to link R&D outputs to practical use
Mechanisms for the identification and protection of intellectual property	Facilities for the education and training of S&T personnel
Policies and programmes to maintain the vitality of the national S&T community.	Mechanisms for the provision of technical services (e.g. meteorology, standardisation, calibration)
	Links to regional and international S&T activities.

(Adopted from IDRC 1993)

It is important at this juncture to highlight some of the key differences between public policy and science and technology policy. It is also worth noting, however, that the two are mutually inclusive as the former is the umbrella and the latter reinforces the latter. The main differences are outlined in Table 2 page 13.

Table 2. Comparison between general policy and Science and Technology policy

General Policy	S&T policy
Elements of policy normally tangible	Elements of policy normally intangible
Outcomes often measurable	Outcomes seldom measurable
Political and ideological intervention normal-domain of politics	Such interventions less common – domain specialised and exclusive
Efficiency and effectiveness are determined in terms of outputs/outcomes	Budgetary growth

(Adapted from Marais, 2000)

As science and technology cuts across all sectors of the economy, it is important to note that the outputs of science and technology are also realized in other sectors rather than under its governing bodies. As indicated in the comparison above (Table 2), outcomes of general policy are often measurable. For example, government policy on education has indicators such as literacy rate, and in the case of health policy, life expectancy. But with science and technology policy, the measurable indicators often referred to as science and technology indicators, are patents and publications, to mention a few. Outcomes and outputs in general policy are expressed in terms of administrative efficiency and effectiveness while with science and technology policy, outcomes are reflected by budgetary growths.

The comparison between science and technology policy and other policies explain why the implementation of science and technology policies is often difficult. That is, the intangible nature of science and technology outputs remains the main impediment to the implementation process.

Finding an appropriate home for science and technology has long been a problem for many countries even in the developed world. Many governments use more than one approach. Among the popular models are:

- Creation of a scientific ministry to deal with S&T policy, either as a ministry in its own right or attached to another ministry.
- The Advisory Councils as mechanism for promoting wide public debate on issues of S&T policy, (for example, in Zambia - Zambian Council for Scientific Research

and the Scientific Council of Canada). In all cases, the advisory councils perform the functions of a secretariat.

- The use of leading National Science and Engineering Institutions or societies as the source of opinion prepared in response to specific requests from government.
- The encouragement of academic groups to work and publish in the field of S&T policy

(IDRC- Mission Report, 1993)

Most southern African countries have adopted the creation of departments of S&T attached to the Ministry of Education. Such countries include Malawi, Mozambique, Namibia, Swaziland, Tanzania and currently Botswana. However, the general practice currently is to establish the Ministry/Department of Science and Technology, and through the adoption of the NSI, the Advisory Councils, R&D institutions etc. are incorporated in the overall national structure of S&T.

2.2 National Systems of Innovations – a theoretical and conceptual framework

The Swedish economist B. Lundvall coined the concept of a national system of innovation. It is designed around Frederich Liszt's concept of national production systems and Von Hippel's work on informal technical collaboration among firms. The main emphasis was on user-producer interaction within the national economy (Marais, H.C. 2000). In order to understand the concept, let me first explain the key words 'system' and 'innovation' as they are implied in the NSI. The word system is widely used in different disciplines such as the communications system, education system and the political system to mention a few. Everett. M. Rogers (1983) defines a system as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal… the members or units of a social system may be individuals, informal groups, organisations and /or subsystems". In policy studies, the term system is often defined in an instrumental way, for example, *the structures*[14] and processes required to give effect to policy. Noisi et. al (1993) provides a variation of this definition and refers to a system as "*the framework within which the policy is implemented.*" The emphasis in the use of the concept of system is the interrelations and interdependencies within the units. On the other hand, Lall (1992) has proposed that innovation includes all efforts towards technological mastery, adaptation of the technology to new conditions and improvements in the technology (either slightly or significant). The stimulus for the development of technological capabilities

[14] Structures are defined as the patterned arrangements of the units in a system (Everett, 1983).

comes from international trade. Niosi et.al (1993) define innovation based on Schumpeter' s classical theory and states that innovations are "*new and improved products and processes, new organizational forms, the resources and the opening of new markets*." However, Niosi et al. (1993) indicate that this definition was broadened by Freeman's (1988) suggestion that social innovations in the field of technology policy had to be included in the definition shifts, which are the results of a change in technology that is so fundamental that the whole economy is affected. Technological innovations are increasingly becoming relevant to national economies, as 'there are politically driven linkages and determinants, such as science and technology policies, that are basically national in scope. Hence Freeman (1988) defines a national system of innovation as "*...the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify ad diffuse new technologies.*"

These two definitions put together generate the definition of NSI. The NSI can therefore, be expressed as;

> *"The systems of interacting private and public firms (either large or small), universities and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal social and financial, in as much as the goal interaction is the development, protection, financing or regulation of new science and technology. The NSI is made up mainly of four elements, namely, institutions, the incentive system, the national technological and scientific capabilities and the state in its regulatory and promotional functions."* (OECD, 1999).

Freeman and Perez (1988) further describe some categories of innovations. These include: (a) incremental innovations which tend to occur continuously often outside the ambit of formal Research and Development (R&D)[15] structures, resulting in improvement in productivity, (b) radical innovations which are discrete breakthroughs resulting from planned goal-oriented programme of R&D, (c) changes in the prevalent "technology system" which affect several related sectors and involve a co-ordination among various firms across sectors; these have

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[15] R&D is the creative work undertaken on a systematic basis on order to increase the stock of knowledge, including knowledge of humankind, culture and society and the use of this stock of knowledge to devise new applications. In this definition, R&D includes the performance of science and technology involving the social sciences, medicine, engineering, natural and physical sciences (DACST: White Paper on Science and Technology 1996).

compared to Schumpeter's "constellation" of innovations, and (d) "techno-economic paradigm"[16].

It is evident from the explanations of the NSI that it is a crosscutting system that brings all the key players in economic development together. It has been indicated earlier that there are linkages and interactions among the units of a NSI. This perception brings to ones mind two questions, namely; what are the basic conditions necessary for the proper functioning of the NSI? And how does a country operationalise its NSI? In order to address the former, a country has to ensure that it has in place a set of institutions, organisations and policies which give effect to the various functions of NSI and to ensure that there is in place a policy environment designed to promote innovation. In the case of the latter, the process by which these interactions occur involves the following:

- Financial flows; with public financing of innovation holding the first place, but also including private financing of innovation and capital investment.
- Legal and policy links, with intellectual property rules, technical standards, and technology and procurement policy applying basically to all national firms, and bringing some degree of state co-ordination among units.
- Technological, scientific and informational flows, market-driven, domestic, scientific and technical collaborations and interactions.
- Social flows, with organizational innovations flowing from one firm to other, and personal flows mainly from university to industry, but also from firm to firm.

(Niosi et al. 1993)

Most countries have designed their NSI models to fit the above-mentioned links. For example, the networks include bodies that deal with the financing of the innovations, S&T policies and R&D institutions within the NSI. These networks require structural arrangements to enable the proper functioning of NSI i.e., to allow for the interplay of all the units of the NSI. It was traditionally believed that NSI is highly centralized, the understanding was that the classical diffusion model (an innovation originates from some expert source, often an R&D organization) dominated the thinking of scholars and policy makers' (Rogers E. M. (1983). However, it was later observed by other scholars that the classical diffusion model fails to

[16] Perez (1988) defines a techno-economic 'paradigms … an interrelated system based on a set of shared principles which forms… common sense of engineers, managers and investors.'

capture the complexity of relatively decentralized diffusion systems in which innovations originate from numerous sources and evolve as they diffuse via horizontal networks. It therefore follows that there are basically two structural networks within the NSI namely the centralized and decentralized diffusion systems. In a nutshell, 'the centralized diffusion systems are based on a linear, one-way model of communication' (Rogers E. M. 1983). While decentralized diffusion systems follow a convergence model of communication in which participants create and share information with one another in order to reach mutual understanding.

There are basically two models of innovative capacity. B. Diyamette (2001) clarifies them as follows:

> *According to the technology-push model, innovative activity is triggered as a result of basic research in science resulting in a widespread use of new processes. According to the model, there is linear progression from a basic research to production and marketing and by investment in R&D has been used as a major indicator of innovation.*
>
> *The demand-pull models of innovation posit innovations as an interactive rather than linear response. This is influenced by learning processes and routing activities generated in production, distribution and consumption. These activities make important inputs into the process of innovation, and are transmitted through at least three channels:*
>
> - *Learning by doing which increases the efficiency of production operations.*
> - *Learning by using (Rosenberg, 1982) increasing the efficiency of use of complex systems.*
> - *Learning by interaction (Lundvall, 1988) involving user and producer interactions resulting in product innovation.*

Marglin (1990) sets out four parameters which indicate a specific knowledge system: its epistemology, its modes of transmission and inter-temporal self-perpetuation, its modes of innovation which determine its adaptability and dynamism over time, and the expression of power, both within the system, in terms of power concentrations and relations among its constituents and with respect to other knowledge systems.

The analysis of national system is thus to map out the web of complex institutional relationships that constitute and determine the content within which a nation's "stock" of technological capabilities and the consequences are shaped.

The use of the concept of a national system of innovation as a framework for policy is an attempt to signal a radical departure from the old view (individualistic science) to the recognition of science and technology as major agents of development. Three principal reasons underlie the utility of the concept of a national system of innovation as a framework for policy analysis:

- It affords an opportunity to think of means for the promotion of coherence and integration among national activities;
- It offers a means of identifying the needs (through interactions).
- It focuses attention on 'innovation'- on doing new things in new ways rather than simply on the production of knowledge.

  The main functions [17] that need to be present in an effective NSI are expounded as follows;

Central Government Functions

1. Policy formulation and resource allocation at national level:
   - Formulation, implementation monitoring, and review of policies and in some countries, plans concerning national S&T activities.
   - Linkages to other policy domains (e.g. dealing with the economy, trade education, health environment, defence etc.)
   - Allocation of resources to S&T from overall budget and first allocation among activities.
   - Creation of incentive schemes to stimulate innovation and other technical activities.
   - Provision of a capacity to implement policies and to co-ordinate appropriate.
   - Provision of a capacity for forecasting and assessing the likely directions of technical change.

[17] An elaboration of the activities undertaken in the NSI is provided in various papers and reports such as the " *Ten years of Reform of Chinese Science and Technology: An International Review of experiences"* A Report commissioned by the State Science and Technology Commission of China and IDRC, Canada and *"Technology Development, Diffusion and Extension Services in Columbia"* A Report to the Department of National Planning of the Government of Columbia, sponsored by the Government of Japan, the World Bank and UNDP. November 1996.

2. Regulatory function
   - Creation of a national system for metrology, standardization and calibration.
   - Creation of a national system for the identification and protection of intellectual property.
   - Creation of a national system for the protection of safety, health and the environment.

Shared implementation functions

3. Financing of Innovation-related Activities
   - Management of financing systems appropriate to the implementation of the other functions of the system.

4. Performance Functions
   - Execution of scientific or technological programs, including R&D and the provision of scientific services.
   - Provision of mechanisms to link R&D output to practical use.
   - Provision of mechanisms to improve access by small and medium scale enterprises to needed technology.
   - Provision of linkages to regional and international S&T activities.
   - Provision of mechanisms for evaluating, acquiring and diffusing best-practice technologies.
   - Creation of innovative goods process and services embodying the results of S&T activities.

5. Human Resources Development and Capacity-building Functions
   - Provision of programs and facilities for the education and training of S&T personnel.
   - Provision of programs to promote international training of S&T personnel.
   - Provision of programs to promote improved management of technology.
   - Creation of institutional capacity in S&T.
   - Provision of mechanisms to maintain the vitality of the national S&T community.
   - Stimulation of public interest in and support of national initiatives in S&T.

6. Infrastructure Functions
   - Establishment, operation and maintenance of information services (including libraries, data bases, a system of indicators and communication systems)

- Establishment, operation and maintenance of technical services (e.g metrology, standardization, and calibration) and services to promote improved industrial design.
- Establishment, operation and maintenance of mechanisms to promote productivity and/or competitiveness.
- Establishment, operation and maintenance of a system of awarding, recording and protecting intellectual property.
- Establishment, operation and maintenance of mechanisms to ensure the protection of safety, health and the environment.
- Establishment, operation and maintenance of any major national facilities for research.

The following table provides a summary of functions undertaken by stakeholders in the NSI.

Table 3 The summary of functions undertaken by stakeholders in the national system of innovation.

Executing agencies	**Core Functions of Government**		**Implementation**			
	Policy & resource allocation	*Regulatory policy setting*	*Financing of innovation Activities*	*Performance of innovation activities*	*HRD & capacity building*	*Provisional infrastructure*
Policy Agencies	Key role	Decision – Making	Supervision	Limited involvement	No direct involvement	No direct involvement
Legislative Bodies	Their key role	Another important role	Supervision	Supervision	Supervision	Supervision
Science councils	May have advisory role	May have advisory role	Some have a key role	Most are extensively involved	Mixed levels of involvement	Some play important role
Departments	Involved in executing decisions	Some have a role	Some finance S&T activities outside government	Some may perform S&T activities	Currently limited	Some involvement in some cases
State corporations	Limited	No role	Some contract out R&D activities	Some are important sources of innovation	No direct involvement	No direct involvement
Defence forces	Role within the defence sector	Limited involvement	Within the defence sector	May have extensive involvement	Some involvement	Some involvement
Other S&T institutions	Some may have an advisory role	Limited involvement	Limited	Key role	Limited	Some have key role
Advisory bodies	Their key role	Should contribute	No role	No role	No role	No role
Other levels Government	Usually no role	A local role in some areas of regulation	Limited, but could be expanded	Limited role	Limited	No direct involvement

Source: Adopted from UNESCO, January 1997.

In a nutshell one learns from Table 3 governments have the support of other agencies in the implementation of the NSI. For example, the policy agencies, legislative bodies and advisory bodies are active undertakers of policy and resource allocation. The legislative bodies are also key players in regulatory policy setting. The science councils appear to be extensively involved in financing of innovation and performance of innovation activities. Some science councils play an important role in the provision of infrastructure. Their inclination may be persuaded by their R&D activities. Some defence forces are also active performers of innovation in order to attain military supremacy and to generate income from the sale of arms.

Stemming from the recognition of the varieties of activities undertaken by various stakeholders within the national system of innovation. It may be concluded that in addition to the facilitation of information sharing, the NSI also addresses the question of division of labour between the public sector and other organisations (Edquist 1997).

Chapter 3 The Malawian Case Study

3.1 Background

Malawi, just as any African country aspiring to reach the levels of developed countries of the world, sought its developmental path through the applications of science and technology. The advent of science and technology as the developmental tool in Malawi came from the recommendations of the Conference of Cabinet Ministers responsible for the Applications of Science and Technology to development in Africa (CASTAFRICA 1) which was held in Dakar, Senegal from 21 to 30 January 1974.

3.2 The notion of the National System of Innovation in Malawi

The notion of a NSI is at its infancy stage in Malawi. This explains why there are no clear indications of how the system will operate, although competitiveness and productivity are based on the NSI. Malawi recognizes the need 'to create an enabling environment for the interaction between the public and private institutions.' (Malawi Science and Technology Policy-2002) The following strategies are recommended to facilitate the NSI in Malawi:

- Create fora for interaction between the productive system on the one hand and the scientific, technological, educational and training systems on the other; to promote productivity and innovation through diffusion and training programmes.
- Create fora for interaction between the productive system on the one hand and the financial and administrative systems on the other to provide financial support and regulatory incentives for innovative ventures.
- Develop human resources and establish and strengthen institutional structures that promote productivity and innovation; and
- Establish institutional capability for technology monitoring and forecasting at the enterprise level in order to support technology management activities like diagnosis, evaluation and development of enterprise specific strategies and projects.

- It is also important for the government to undertake comparative studies of the performance of the NSI in other countries to learn from their experience and adopt working models suitable to the country's needs.

It has been learned from the strategies mentioned earlier that Malawi wishes to establish linkages between the productive sectors, education and scientific and technological sectors. Malawi also attaches productivity to enterprise development.

3.3 The Key Science and Technology Policy Goals

As a starting point, the government of Malawi redefined its science and technology policy stance through the review of the first National Science and Technology Policy, an exercise that brought about the newly adopted *Science and Technology Policy for Malawi 2002*.

The main thrust of the policy is "to maintain sustainable socio-economic development through the development and applications of science and technology in order to improve the standard and quality of life of Malawians." Science and Technology Policy for Malawi - 2002).

The Malawian policy goals encompass a wide variety of local needs as the improvement of the quality of life calls for a lot of developmental interventions that can be defined by the general policy objectives:

- Establish a national capacity for research and development technologies.
- Raise productive capacity and improve competitiveness through efficient applications of technologies.
- Promote traditional, endogenous, new, and innovative technologies.
- Create and develop science and technology awareness and culture.

(Science and Technology Policy Malawi - 2002).

The main features of the policy are:

- Strengthening of the national science and technology system and its integration with national development.
- A call for the development of larger and qualified human resources for science and technology programmes implementation.
- An emphasis on the interaction between technologists, scientists and engineers with policy makers, industrialists and other stakeholders.
- The establishment of sectoral objectives for high priority areas such as education; agriculture, food and nutrition; health and population; energy; industry; commerce; environment and natural resources; communications; transport.
- A proposal for the appointment of a parliamentary committee on S&T and a Cabinet Committee on S&T and the establishment of an institutional and legal framework to promote S&T.

(Phiri, 1999 and 2000).

Malawi has embarked on a number of steps to facilitate the translation of the policy goals into action. The most significant step has been the recommendation to restructure the science and technology management structure to a centralized one. This will be facilitated by the creation of the National Science and Technology Commission (NSTC). The NSTC will ensure accountability and the monitoring of the S&T system. The other important venture has been the move towards implementation of the NSI. The next discussion elaborates on the National Research Council of Malawi.

3.4 The National Research Council of Malawi.

The institutionalisation of science process began with the establishment of the National Research Council of Malawi (NRCM) in 1974. The main functions of NRCM are to formulate the national S&T policy and to advise the government of Malawi on issues related to the technological and scientific development in Malawi, and to promote and co-ordinate the development and applications of research. The NRCM is currently placed in the Office of the President and Cabinet. The council membership includes representatives from both public and private sectors.

The research institutions in Malawi can be divided into four groups:

- *Public Research Institution or Departments.*

  These are established and controlled by government. These include the Department of Agricultural Research and Technical Services (DARTS), Health Science Research Unit (HSRU) and Malawi Institute of Education to mention a few.

- *Statutory Research Institutions*

  These are state assisted institutions but work outside normal government setting. The most notable is the Malawi Industrial Research Technology Development Centre (MIRTDC). The other statutory research institute is the National Herbarium and Botanical Gardens (NHBG).

- *Tertiary Education Institutions*

  These are mostly research institutes formed under the university of Malawi. These include, Colleges of Bunda, Chancellor College, College of Agriculture, the College of Medicine and Kamuzu College Nursing and the Polytechnic. In addition the University established following research centres; the Centre for Education

Research and Training (CERT), Centre for Social Research (CSR) and the Agriculture Policy Research Unit (APRU).

- *Private Research Institutions*

  These are research institutions by associations to conduct research mainly in the areas of agricultural commodities - Tea Research Foundation (TRF) and the Agricultural Research and Extension Trust (ARET) responsible for research on tobacco.

(Phiri, 1999 and 2000)

The NRCM has not been able to make a significant impact on the development of science and technology system due to the following reasons:

- A lack of clear direction on S&T by government prior to the endorsement of vision 2020.
- The instability and uncertainty surrounding institutional aspects of the NRCM, which has resulted in the NRCM changing status four times in ten years.
- Inadequate funding and staffing of the NRCM, making it difficult for the council and its committees to function properly.
- Lack of parliamentary mandates for its functioning.
- Inability to co-ordinate and direct research without the power to influence budgetary considerations as public research institutions are attached to line ministries with direct funding and reporting lines.

(Phiri, 2000)

It was only sixteen years after the NRCM establishment that the first National Science and Technology policy was developed and adopted in 1991. Regrettably, however, the policy could not meet its intended goals due to the following reasons:

- The country's pluralistic approach[18] in the management of Science and Technology;
- Lack of integration of the policy in the overall development plans of government;
- Lack of human, financial and material resources; and
- Lack of necessary supporting legislation.

(Science and Technology Policy for Malawi. June, 2002)

[18] A system that allows each ministry, department or institution to make fundamental decisions on research capacity, priorities and funding without the benefit of coordinating mechanism.

Upon the realization of the above-mentioned problems, the Government of Malawi attempted to harmonize science and technology activities with the major activities of the NRCM, namely the promotion and coordination of the development and applications of research.
The execution of the science and technology system in Malawi through the NCRM is presented in Figure 3.1.

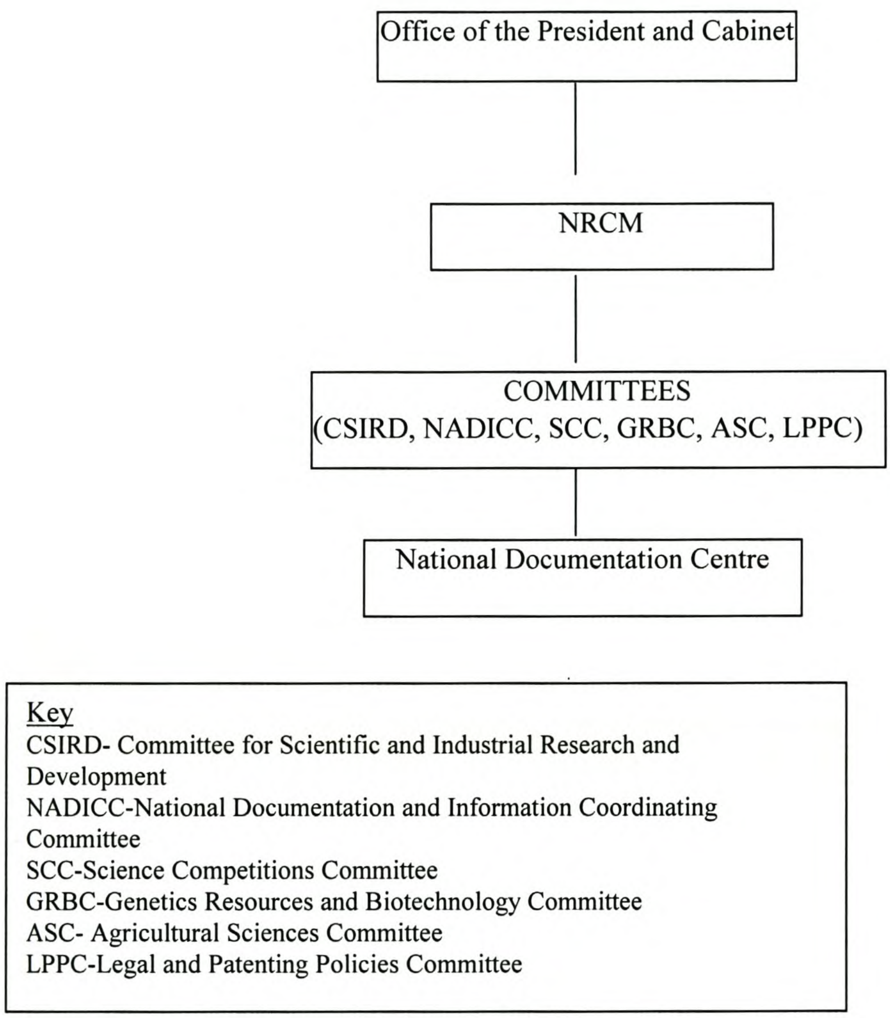


Figure 3.1 NRCM STRUCTURE

The next section describes the new national science and technology system in Malawi.

3.5 The Science and Technology structures at Level National

There are basically four levels of science and technology management in Malawi.

Level 1: *Decision making and planning,*

Level 2: *Promotion, Financing and Co-ordinating.*

Level 3: *Execution of Research and Development.*

Level 4: *Scientific and Technological Services.*

Level 1 : Decision Making and planning

At the top of the hierarchy of the system is the State President and Parliament, followed by the Cabinet and the National Economic Council. Below the Cabinet are the different ministries and under the National Economic Council is the National Statistical office.

Level 2: Promotion, Financing and Co-ordinating

Level 2 is the Division that deals with Promotion, Financing and Coordination of Science and Technology. This level comprises the NRCM and its committees, the Treasury, Agricultural Research Council, Health Research Council, and the National Committee on the Environment, International Cooperation, the Registrar General's Department and the Factories Inspectorate.

Level 3: Execution of R&D

Level 3 deals with the execution of R&D. Its main components are the institutions of higher learning such as the Universities and Colleges, Research Stations, specialized research units such as the Fisheries, Forestry, Geology, Central Water laboratory, Surveys departments, Malawi Industrial Research and Technology Development Centre (MIRTDC), Community Health Services Unit (CHSU), National Herbarium and Botanic Gardens of Malawi (NHBGM), other Departments – Department of Agricultural Research and Technical Services (DARTS), Department of Parks and wildlife, and the Malawi Bureau of Standards (MBS).

Level 4: Scientific and Technological Services

Level 4 is concerned with scientific and technological services. This level essentially deals with science and technology information and services. It is composed of the National Documentation Centre, Association for the Advancement of Science and Technology of Malawi (AASToM), National Statistical offices and Meteorological Department.

The NRCM appears to be placed parallel to the other science and technology sectors; hence, it is not elevated above these sectors as a coordinating body. This signifies that science and technology decision-making process follows a 'pluralistic approach' in which each sector independently deals with its affairs without a formal consultation with the NRCM. The NRCM's inability to co-ordinate and direct research results from its lack of financial power, that is, the NRCM does not possess the influential capacity on budgetary considerations.

Cardinal to all these problems mentioned earlier has been the instability and the uncertainty surrounding the institutional aspects of NRCM. The NRCM has never had a steady home from when it was placed under the Office of the President and Cabinet. For example, the NRCM was established with a Secretariat in the office of The President and Cabinet. Later, NRCM's activities were merged with those of the Environmental Affairs from the then Ministry of Forestry and Natural Resources in 1988. In 1991, the Secretariat was elevated to a full department. In September 1994, the Government elevated the department to a full Ministry called the Ministry of Research and Environmental Affairs. 'The NRCM was reconstituted in July 1997 following the abolition of the Ministry of Research and Environmental Affairs and reverted back to Office of the President and Cabinet' (Science and Technology Policy Malawi, June, 2002). It can therefore be concluded that the inability of the NRCM to perform as expected can also be attributed to its placement under the Ministry of Research and Environmental Affairs, hence the NRCM's activities were not given a priority.

3.6 The Proposed new Structures of Science and Technology in Malawi

It is upon realizing the drawbacks caused by the maladministration of the science and technology sector that the Malawian government sought to review its first National science and technology policy and developed the new science and technology policy recently adopted (June 2002). In order to address the main problems that characterized the failures of the first S&T policy the new science and technology policy proposed the following steps:

Financing of Science and Technology

The Government of Malawi concurs with the United Nations Education, Scientific and Cultural Organization's (UNESCO) recommendation of allocating 1% of the Gross Domestic Product (GDP)to R&D. To this effect, 'the Government of Malawi will under the National Science and technology policy allocate from public resources not less than 1% of GDP to R&D and adequate funding to science and technology activities by the year 2005' (Science and Technology Policy, Malawi-2002). Furthermore, the Government intends to establish a fund for the advancement of science and technology under an Act of Parliament.

Institutional and Legal Framework
The Government of Malawi through its National Science and Technology Policy has recommended the establishment of a National Commission for Science and Technology (NCST) as the science and technology advisory body to the Government. The NCST will be placed under the Office of the President and Cabinet. Figure 3.3 illustrates the structure of NCST and the main components of the NCST are as follows:

- Commissioners

The commissioners will be made up of eight members from industry, academia, R&D institutions or individuals prominent in science and technology. Commissioners will be appointed in accordance with the Science and Technology Act.

- Parliamentary Committee responsible for science and technology

The Parliamentary Committee will serve as the advocate for science and technology matters in the National Assembly. However, who the members of the committee are is not indicated.

- Cabinet committee responsible for science and technology.

The main purpose of the Cabinet committee is to monitor the development and application of science and technology in the national development process.

- Secretariat

A commission secretariat will be established to implement the programmes of the NCST. The Secretariat will be organized under the following directorates :

  - Policy, Planning and Training
  - Research and Technology Transfer
  - Documentation, Communication, Information and science and technology indicators
  - Administration and Finance

Compare with Figure 3.2. page 34.

- Sectoral committees

These are the "eyes and ears" of the commission within the ministries, they will serve as the links between the ministries and the commission. The Science and Technology committees comprise the following key sectors: Agriculture, Health, Industrial Research and Development, Natural Resources, Education and Social Science Research and the Universities.

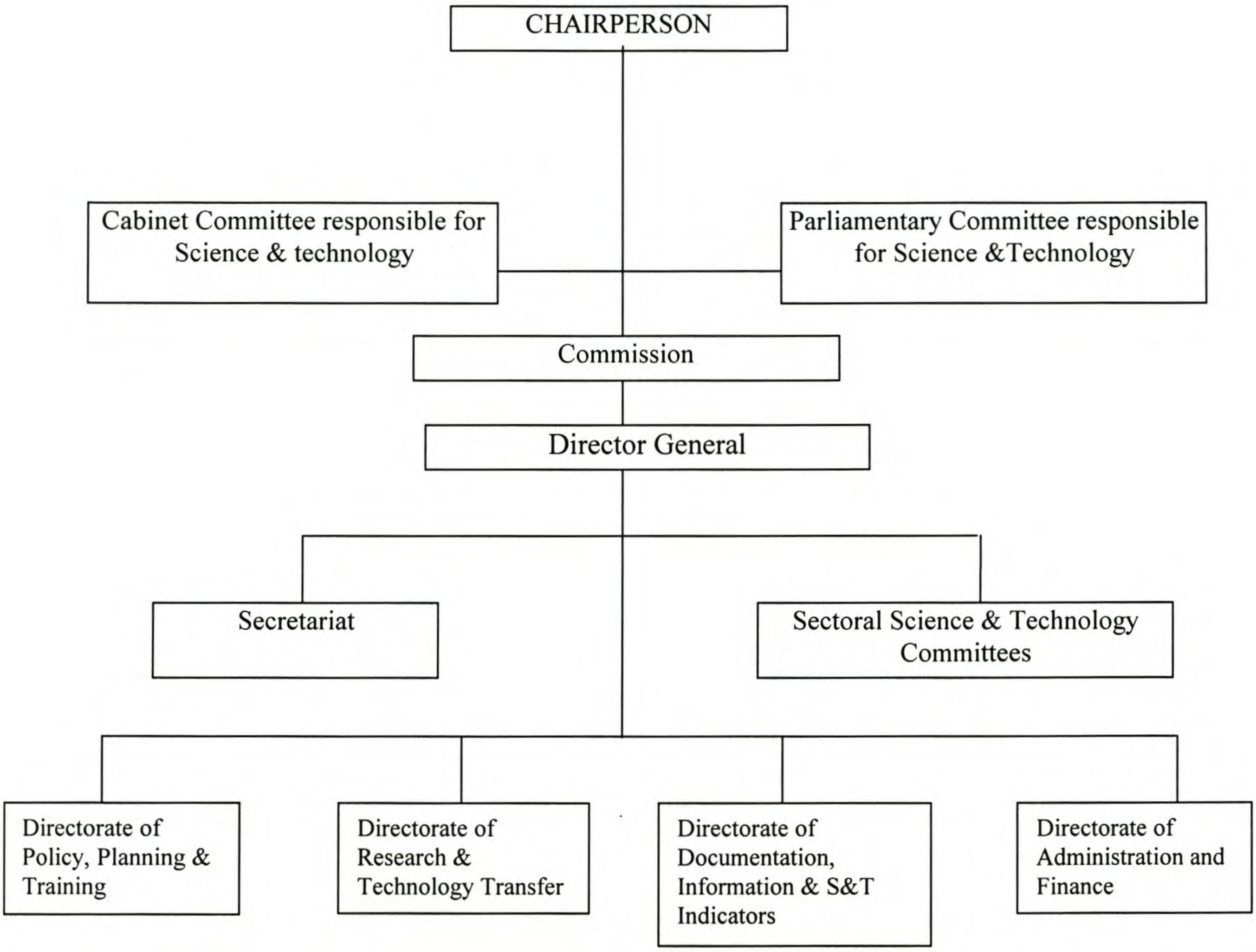


Figure 3.2 Structure of the NCST

3.7 Conclusion

The management of science and technology in Malawi follows the model that has been suggested by IDRC (1993), in which the Advisory Councils are mandated to take the leading role. In the case of Malawi, the NRCM assumed the responsibility of S&T research co-ordination.

The main shortcoming the Malawian system of S&T has been the poor co-ordination mechanisms due to the pluralistic approach to administration resulting in fragmentation of science and technology activities. The Malawian experience demonstrates a system that suffered the consequences of poor control over science and technology matters. There are no clear links between NCRM and the other sectors hence accountability on the science and technology activities are compromised. It therefore follows that co-ordination is of the key essence to the management of science and technology, that is, a concerted effort is needed from all role players in Malawi to establish a fully functional system and to avoid duplication of efforts.

However, Malawi took a brave step in the right direction by reviewing the first policy and restructuring the system to allow for the smooth running of the new S&T system. It is hoped that following the adoption of the current science and technology policy, the Government of Malawi will undertake the necessary steps towards an immediate creation of the proposed institutions in order to facilitate the adoption the implementation of the policy.

Chapter 4 The Namibian Case Study

4.1 Background

Science and Technology in Namibia is geared towards an integrated approach whereby the education sector will be transformed to serve the needs of industry and commerce with emphasis on value–adding. The Minister of Higher Education, Vocational Training, Science and Technology reiterated this stance in his remarks in the foreword of the National Policy on Research, Science and Technology, 1999. He stated:

> *"This forces us to tilt our education system in the direction of science and Technology... We need to double the number of qualified teachers and learners in mathematics, science and technology fields. Equally, we need to see a compatible shift in attitude and response of our business sector and for business, teaching and research institutions to link efforts and resources to complement the education system and ensure that the skills they provide fit the demand for industry and commerce"*

Namibia just as other developing countries embark upon the implementation of a NSI in science and technology to maintain its economic growth. In the case of Namibia innovation is defined in terms of commercialisation and value adding.

4.2 The Notion of The National System of Innovation in Namibia

The NSI in Namibia is defined as the interaction between the scientific institutions, technical organizations in public and private sector, and science and technology policies in the pursuit of national goals. Emphasis is put on the market-based policies to stimulate public inputs and to necessitate domestic production of both consumer and capital goods and services. The journey to a functional NSI is not an easy one, as there are challenges that need to be resolved to make way for the NSI in Namibia:

- Lack of technical skills.
- Low level of public awareness on the role and benefits of science and technology in economic development.
- The imbalances in the R&D activities and output due to racial and ethnic differences.

In the light of these challenges, the government undertook the following strategies:

- Developed simplified science and technology literature
- Popularised the use of science and technology infrastructure, for example, museums and S&T information centres

- Provided S&T incentives (prizes and awards)

(National Policy on Research, Science and Technology Policy 1999).

In addition to the above-mentioned strategies the government took a step further and introduced the following policy reforms in order to create an enabling environment for the introduction of the NSI:

- Advocated for the revision of the science curriculum from basic level to tertiary levels
- Introduced quality teaching, experiments in schools and after school work experience
- Encouraged research activities at tertiary level, research institutions, private laboratories and Regional Innovation Centres.

(National Policy on Research, Science and Technology Policy 1999).

The NSI in Namibia is designed around trade development through value adding. The interactions are between the education sector, trade and industry, and research institutions. As much as the NSI in Namibia departs from the improved education curricula that integrates science and technology subjects, Namibia seems to be a long way behind its trading partners (Newly Industrialized Countries (NICs) and the developed world) as it has to develop the human resources capacity from basic levels of education. Although capacity building is vital to innovation, it is also important to direct the resources to groups that will generate immediate outputs such as tertiary institutions.

The NSI in Namibia can be summarized as follows:

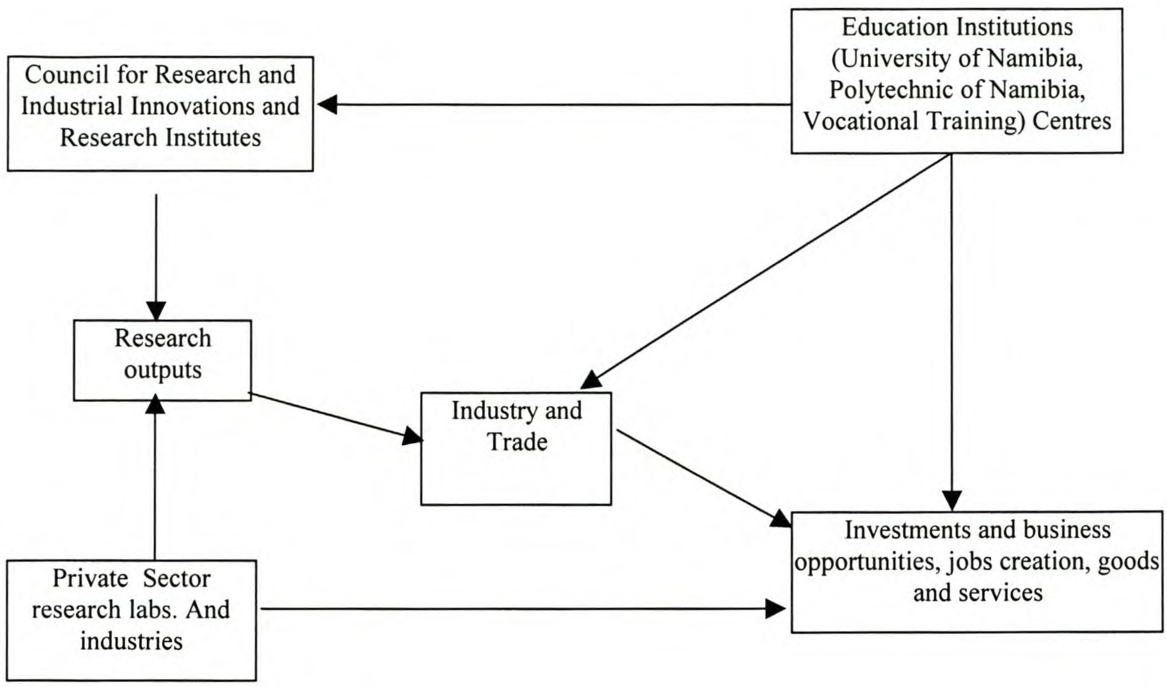


Figure 4.3 National System of Innovation in Namibia

In summary, Namibia views its NSI as comprising of education, training science and research, technology, value added jobs, products, services, wealth and prosperity.

4.3 The Key Science and Technology Policy goals.

In order to satisfy the elements of the mission and vision the following goals were drawn up:

- Develop a supportive legal framework for research, science and technology.
- Ensure that appropriate human and institutional resources for research, science and technology are in place.
- Popularise research, science and technology.
- Enhance applications of research, science and technology for the benefit of the Namibian people.
- Develop a knowledge management system.
- Establish and maintain national systems for coordination.

(Directorate Research Science and Technology, 1999).

In order to operationalize the above-mentioned goals, the government established an enabling legislation, to provide support and the legal impetus of the dictates of the Research Science and Technology Policy, and a comprehensive development strategy that includes the attraction and retention of technical skills. Although the science and technology goals embrace the core mandates of a functional science and technology system, the implementation strategies are biased towards entrepreneurial development and the retention of technically competent personnel. There is very little reference as to how other productive sectors will be integrated into the NSI as the driving principle of the Research Science and Technology Policy.

However, Namibia has introduced a number of infrastructural reforms designed to facilitate the implementation of the policies. These include the creation of S&T support structures such as, policy advisory bodies (National Council of Research Science and Technology-NCRST), innovation fund management (Foundation of Research Science and Technology, FRST and Council for Research and Industry Innovations, CRII), science and technology education (Council for Science & Technical Education, CSTE) and Council for Vocational & Industrial Training, CVIT) and the S&T information (Science and Technology Information Centre, STIC). I will elaborate on these institutions under the science and technology structures in Namibia.

4.4 Namibian Science and Technology Vision

As people in a newly emerging nation, Namibians have their dreams about where they want to see their country in the future in this era of globalisation. It is their wish to secure a steady rise and a balanced growth in GDP activities as national wealth and income are expanded; to spread prosperity and advance the quality of life of Namibians. These impacts will be sustained through a national system of innovation, improving skills and knowledge, systems for science and technology management and coordination and the use of science and research to integrate technical education with production, commerce and our resources (Directorate Research Science and Technology, 1999).

4.5 Namibian Science and Technology Mission

Taking cognisance of the need to be competitive both regionally and internationally, the Government of Namibia is determined inter alia; 'to spearhead, coordinate and expedite the development and implementation of appropriate policies, infrastructure and institutional arrangements: to advocate the mechanisms necessary to encourage research, technical and scientific education, innovations and their output; and to establish and maintain value adding linkages between and among Industry, Commerce, science and technology institutions and the broader community' (Directorate Research Science and Technology, 1999).

It is obvious from the vision and the mission statement that the corner stones of science and technology development in Namibia are education and industrial development. It is therefore understood that most of the policies that evolve form the Directorate of Research, Science and Technology, will be trade oriented.

4.6 The Science and Technology structures in Namibia

Namibia experienced great fragmentation of its science and technology activities due to the absence of co-ordinating mechanisms. Realising the crosscutting nature of science and technology, the Government of Namibia created the Ministry of Higher Education, Vocational Training, Science and Technology (MHEVTST) and the Research, Science and Technology Directorate (RSTD) was established under it in 1996. MHEVTST operates as the governing body of RSTD and facilitates collaboration between RSTD and the other government ministries and the private sector.

The RSTD is composed of Scientists/engineers in several disciplines including statistics, economics and social sciences. (See the structure in Figure 4.4 pp42) The directorate consists of four divisions namely:

Science and Technology Policy Development and Capacity Building Division

The division generally looks at the science and technology institutional and human needs and;

- Co-ordinates manpower surveys, manpower gap analysis and projections.
- Institutionalizes capacity surveys and analysis.
- undertakes science and technology training.

Research and Technology Development Planning

The section is entrusted with the management of all issues pertaining to research and development, hence it undertakes the following:

- R&D co-ordination.
- Science and technology info-base development.
- R&D funding.

Industry Development and Beneficiation Division

The division deals with technology transfer/acquisition and commercialisation through the following activities:

- Industry and commercialisation liaison for intersectoral linkages and value added development.
- Technology assessments, risk analysis, technology appraisal and development.
- Process and product development, and productivity improvement.

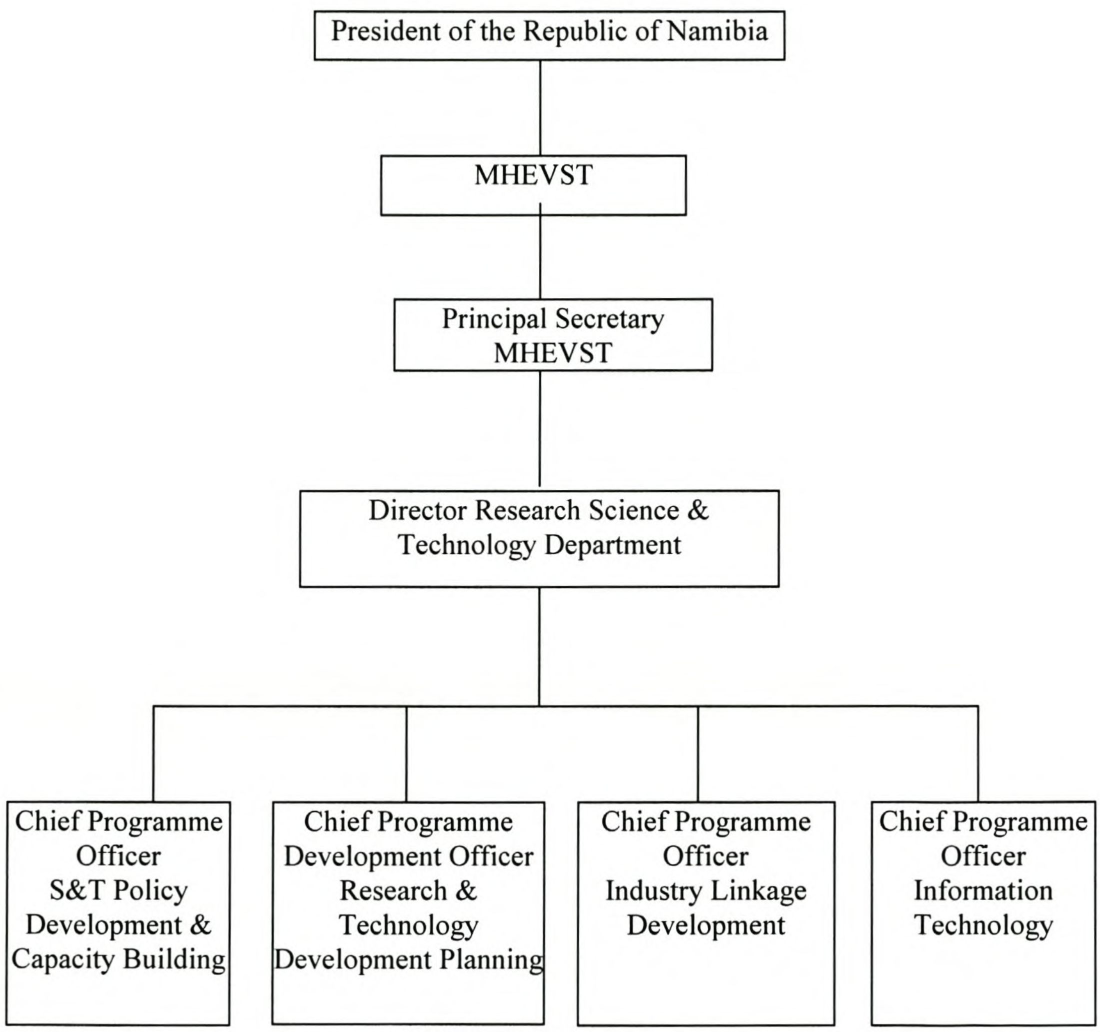
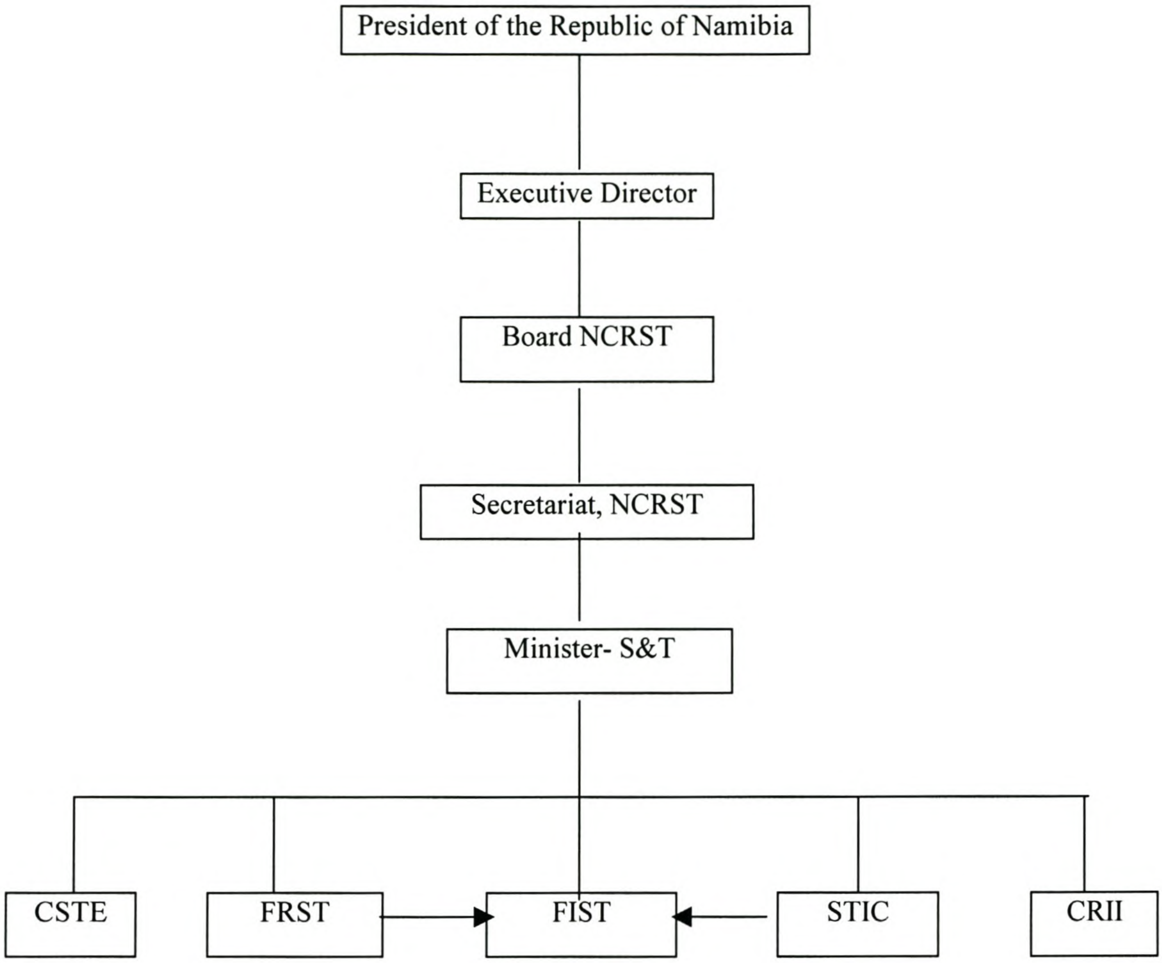


Figure 4.4 The Structure of Science and Technology



<u>Key</u>

National Commission on Research, Science and Technology (NCRST)

Foundation for Research, Science and Technology (FRST)

Council for Research and Industrial Innovations (CRII).

Council for Vocational and Industrial Training (CVIT)

Council for Science and Technical Education (CSTE)

S&T Information Centre (STIC).

Figure 4.5 Structure of the National Commission on Research Science and Technology (NCRST)

Information Technology Division

The division deals with data processing and science and technology information management.

4.7 The proposed new structures of Science and Technology

The recommendations for creating new structures within the science and technology system came through the National Policy on Research, Science and Technology. These institutions are meant to strengthen the existing structure and to provide for the main elements of a functional science and technology system. The new structures are comprised of the following:

- National Commission on Research, Science and Technology (NCRST).
- Foundation for Research, Science and Technology (FRST)
- Council for Research and Industrial Innovations (CRII).
- Council for Vocational and Industrial Training (CVIT)
- Council for Science and Technical Education (CSTE)
- Science and technology Information Centre (STIC).

National Commission on Research, Science and Technology (NCRST) (see the structure in Figure 4.5 page 43).

The NCRST is composed of sixteen members including the chairperson representing the key sectors of science and technology in Namibia. The main functions of the NCRST are to meet twice a year to report on the science and technology programmes, budget, performance and achievements to Parliament. NCRST shall also be the overseer of the science and technology development in Namibia.

Foundation for Research, Science and Technology (FRST)

The FRST is responsible for the administration of the Fund for Innovation in Science and Technology (FIST). It will be the principal organisation in Namibia to solicit, receive and oversee the management of the innovation fund allocated, earmarked or obtained through public subscription.

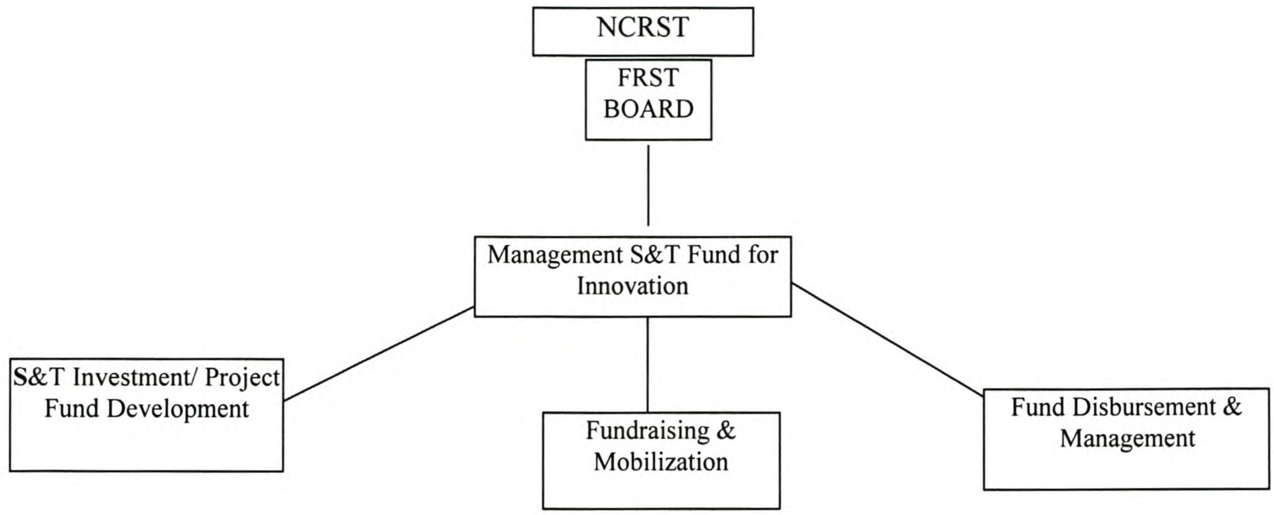


Figure 4.6 Structure of the FRST

Council for Research and Industrial Innovations (CRII).

The CRII operates as a coordinating forum for Research Institutes. It will furthermore work in conjunction with small-scale industrial enterprises and relevant ministries to identify and establish the Regional Innovation Centres.

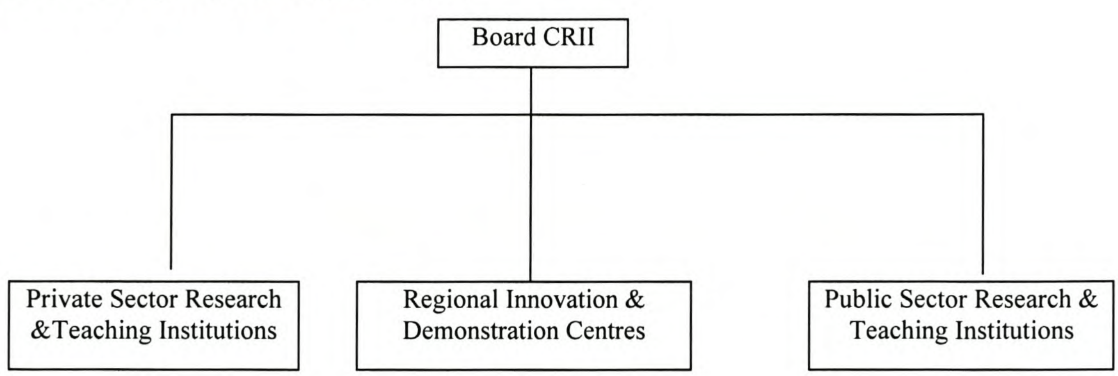


Figure 4.7 Structure of the CRII

Council for Vocational and Industrial Training (CVIT)

The CVIT operate as a coordination body to focalise the development and integration of vocational skills and industrial training practices throughout the country.

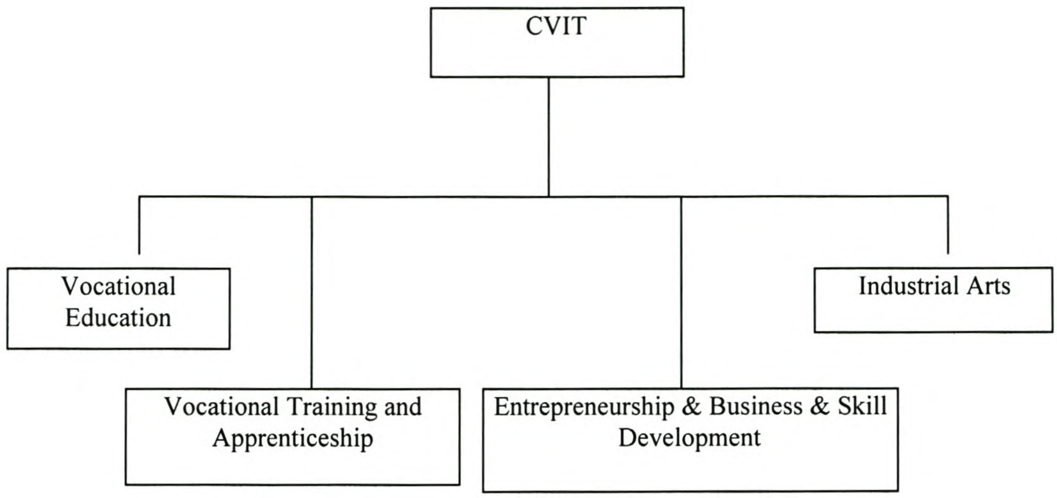


Figure 4.8 Structure of the CVIT

Council for Science and Technical Education (CSTE)

The CSTE (see page 47) focuses on the development of an effective environment for teaching, learning and integrating science, mathematics and computer technologies in schools, education and training systems. In addition, the CSTE will promote centres of excellence in the science, mathematics, technology and computer literacy throughout the education system (National Policy on Research, Science and Technology, 1999.)

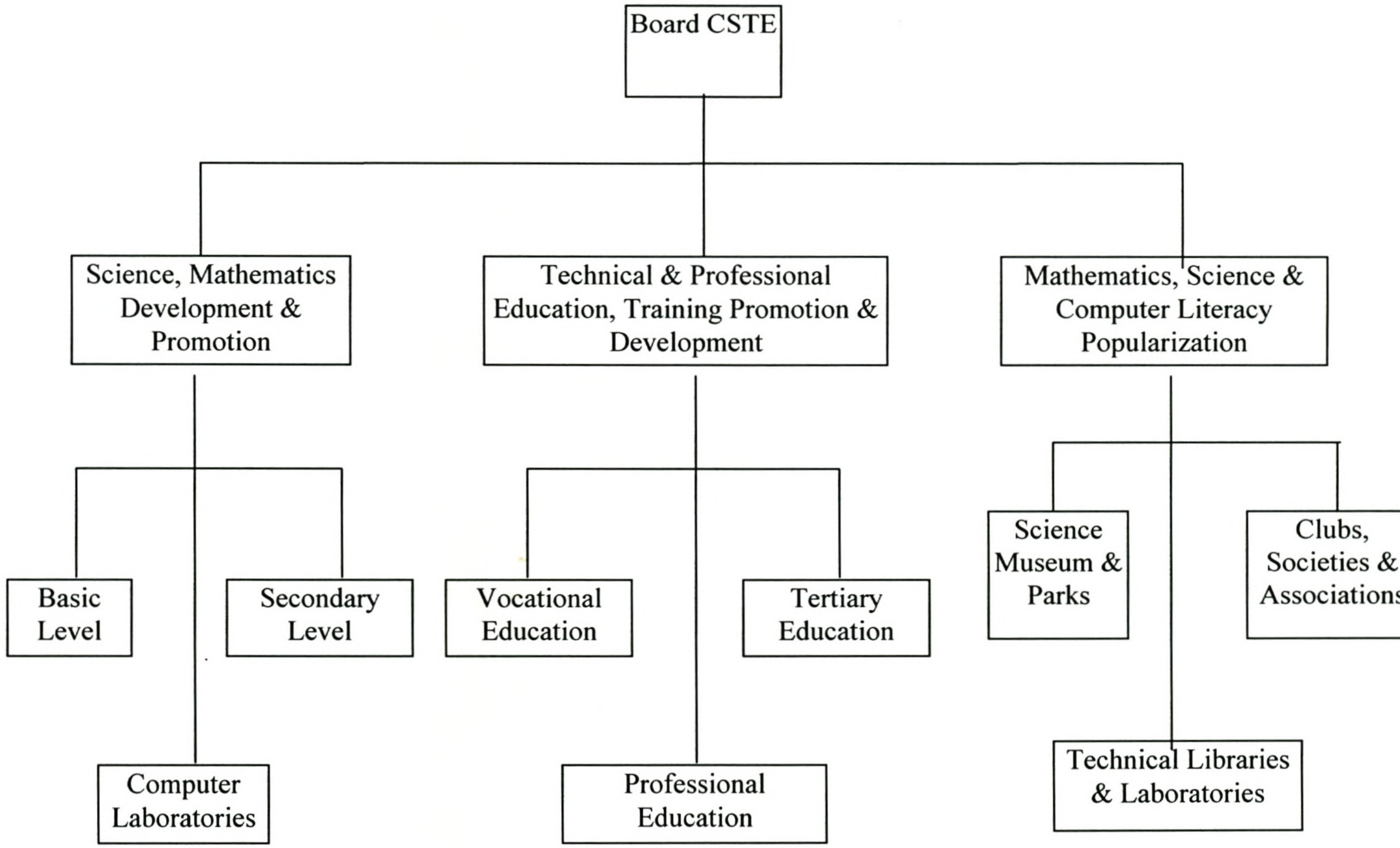


Figure 4.9 Structure of the CSTE

Science and Technology Information Centre (STIC).

STIC will serve as a resource centre for all the above-mentioned institutions and the public at large. The National Policy on Research, Science & Technology (1999) explains the core mandate of STIC as to collect, code, archive, store and disseminate science and technology information.

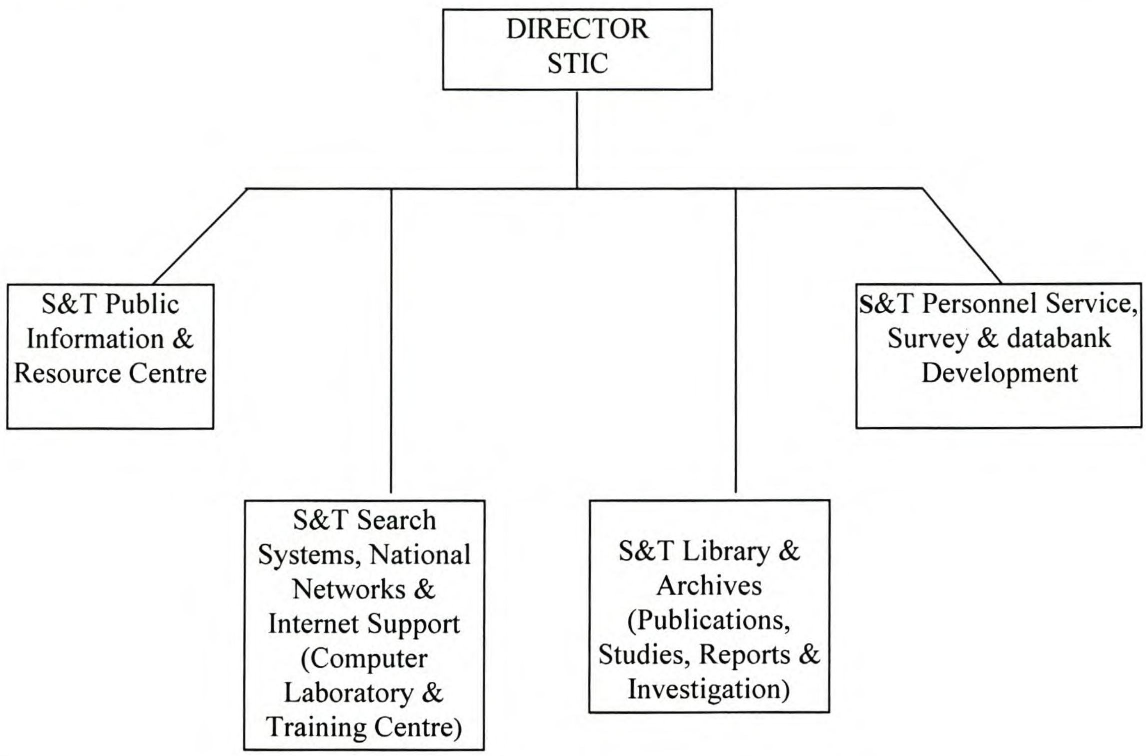


Figure 4.10 Structure of the STIC

4.8 Conclusion

The Namibian Science and Technology system aims at establishing a tripartite relationship between the Education sector, Industry and Research institutions. This is a good move towards the implementation of the policy and provides for a good environment for proper functioning of the NSI. However, the Namibian science and technology system seems to be more inclined towards the education sector, which may jeopardise other productive sectors.

Chapter 5 The South African Science and Technology Structure

5.1 Background

Science in South Africa dates back to the 18th century when science was not considered as a tool for national development but undertaken as a way of achieving self-actualisation and recognition (i.e. for individuals to earn respect from other scientists). However, Boshoff et.al. (1999) indicate that some initiatives towards the institutionalisation of Science in South Africa began with the founding of two public institutions namely the Royal Observatory and the South African Museum, which were used as technical centres by visiting scholars. The establishment of the universities gave rise to the formation of professional associations and most importantly, the institutionalisation of research that was further developed into research councils. Graeme Addison (2000) noted that one of the oldest research centres is the Onderstepoort Veterinary Research Centre, which was developed by Arnold Theiler. Theiler convinced the public that organised scientific research could play an important role in national well-being '… In 1908, he set up the Onderstepoort Research Laboratories… Today Onderstepoort is more than a facility: it is a symbol of science in society, for nearly nine decades it has supported agriculture with a constant flow of advice and innovations.' The advent of research councils after World War 11 in 1940, allowed for communication between and among scientists hence research as a body knowledge generation and sharing was accorded high priority. However, sharing of knowledge could not be facilitated effectively because of the 'political isolationism' Boshoff et.al. (1999) which resulted in international bans and boycotts imposed on South Africa. Hence, individualism still plagued a lot of scientists as they continued with their independent research agendas.

The government support for research was addressed at the time when according to Marais, H.C. (2000) and Graeme Addison (2000) the Government of South Africa commissioned 'Schonland as Scientific Advisor to the Prime Minister and to facilitate the establishment of the Council for Scientific and Industrial Research (CSIR). Schonland adopted the Australian and Canadian research councils as the most appropriate models for his proposal for the establishment of the CSIR, hence the Scientific Research Council Act (Act 33 of 1945). The CSIR was formally established on 5th October 1945. The Scientific Research Council Act paved the way for the formation of other research councils such as the Human Sciences Research Council (HSRC) that was officially established on '1st April 1969 through the Human sciences Research Council Act 23 of 1969' Marais, H.C. (2000). The realization of science and technology as an option for national development continued to be accorded high priority until when the Government decided to consider the development of the science and technology Policy.

5.2 Science and Technology Policy Development in South Africa

The first Science policy in South Africa namely the '*Science Policy and Development Programme for the Republic of South Africa* was published in 1982. It was followed by a *Policy for Technological innovation for the Republic of South Africa* and what was called *Science Policy and System of the Republic of South Africa.*' Marais, H.C. (2000). The developments of these three documents within a short space of time indicate the problem of lack conceptual clarity of the science and technology, and to a large extent show the impact of political isolation suffered by the government of the day as the government could not learn from the experiences of other countries abroad.

A new vision in South Africa dawned during the transition to a post-apartheid system in 1993. That is, a direction into a new thinking was focused on the role of science and technology as the engine of economic growth and political stability. Steps were taken to prepare for a national policy on science and technology. These include among others;

- Collaboration with the African National Congress Research Department.
- Commissioning of the International Development Research Centre (IDRC) to undertake a study on the science and technology policy development in South Africa.

These undertakings generated the debates on science and technology policy issues which resulted in the development of the *Green Paper* and the *White Paper*. It has been indicated earlier that the nationalist government had prepared a policy on technological innovation; this indicates that plans were already underway for the development of a national science and technology policy. At this point it is important to discuss how South Africa give expressions to the NSI.

5.3 The Notion of the National System of Innovation in South Africa

Graeme (2000:88) concurs with Boshoff et al. (2000) that science in South Africa was not understood as a mode of knowledge creation, and observes, "*In the South African experience, the science and technology moved from stasis to dynamism*".[19] Graeme Addison, (2000:88) further elaborates that in the past, 'R&D structures were moulded to meet the needs of a society ruled by a minority and not fully exposed to world trends ... The nationalist government of South Africa came to regard political and scientific isolation as a given and acted accordingly, using science and technology infrastructure to shore up its defences.' The IDRC (1993) holds Greame's position and point out that 'scientific research and technological development were subordinated to the ideology of 'total strategy,' fashioned in order to mobilize the country's resources in defence of white minority rule... Military requirements set the agenda for technological development.' The change in science and technology management came with the realization of the 'free market,' which calls for competitiveness. 'In this system, R&D equates with mental capacities, the power of knowledge ...and human development, because the only tool that can beat a wicked system is constant innovation' (Graeme, 2000:18).

The South African science and technology system is designed around the idea of the NSI.

> *The prime objective of the NSI is to enhance the rate and quality of technology transfer and diffusion from the Science, Engineering and Technology (SET) sector by the provision of quality human resources, effective and efficient users of technology in business and government sector.*
>
> (DACST- White Paper on Science and Technology 1996)

The system was further endorsed in one of the Minister of Arts Culture Science and Technology introductory statements where it was stated, "we believe that this is best done by embedding our science and technology strategies within a larger drive towards achieving a national system of innovation" (Boshoff et. al., 2000). A point of departure for the South African NSI begins with social transformation, where the integration process focuses on the social acceptance of every South African across all racial lines. The heterogeneous nature of the South African citizenry adds value to the NSI due a to rich cultural diversity, which breeds a lot of creativity and innovativeness. It is therefore essential for South Africa to redefine itself and accommodate all forms of knowledge to build a bright future for its citizens. In the same

[19] Dynamism is the ability to absorb efficient use of new technologies and to adapt them to local conditions improve upon them and ultimately create new knowledge.

spirit of social innovation, South Africa opted for a government of national unity led by the African National Congress (ANC).

In the case of South Africa, the implementation of the NSI faced many challenges:

- The historical background is exemplified by the different points of departure from which the apartheid system and the opposition organizations (that is, the ANC) came. The apartheid system had already established structures geared towards economic competitiveness while opposition organizations focused on science as a social contract probably with an attempt to close the racial divide.
- The NSI calls for collaborative partnerships between the research organizations. This was another policy dilemma in view of the fact that the quality and the number of research outputs differ along racial lines. This was indicated by the inequalities in the financial allocations to institutions. The budget allocations for the predominantly "white Universities"[20] (University of Cape Town (UCT), University of Stellenbosch (US), University of Pretoria (UP) and University of Witwatersrand (Wits)) far exceeded the predominantly "black universities"[21] (University of Qwaqwa, and University of the North).
- The other main challenge has been to strive for a structurally inclusive science and technology system, that is, one that harmonizes both the "economic competitiveness" and "social goals" in order to provide for a conducive climate for the NSI.

These challenges call for the creation of a coherent NSI that will accommodate all the key stakeholders of science and technology in South Africa. Figure 5. 11 page 54 summarizes the NSI in South Africa and indicates how research and development impacts economic growth and quality of life.

[20] Universities whose student intake and management is run by the White South Africans
[21] Universities whose student intake and management is run by the Black South Africans

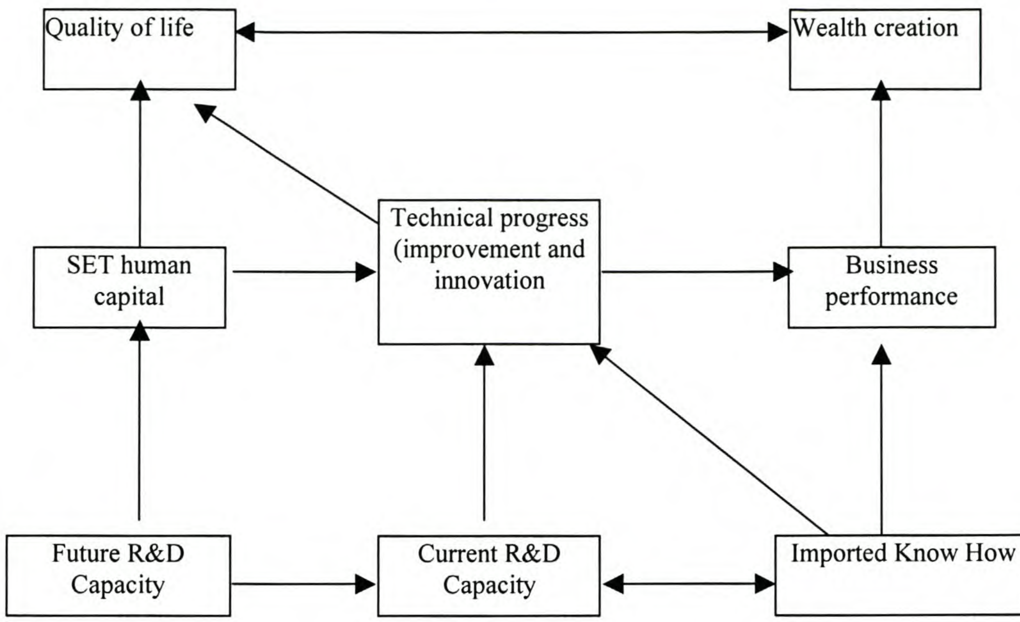


Figure 5.11 National System of Innovation in South Africa
(Adopted from NACI: South African Science and Technology- Key Facts and Figures 2002)

The figure indicates that the NSI strives to achieve two major goals namely, quality of life and growth and wealth creation. These goals are achieved through the use of Science Engineering and Technology (SET) human capital, technical progress (improvement and innovation) and business performance. In order to sustain the system, the government has to develop future R&D capacity, current R&D capacity and invest in imported know-how.

Scerri. M. (1995) observes that the local sellers of innovations are the government agencies such as the Council for Scientific and Industrial Research (CSIR), tertiary education institutions and independent research laboratories. In addition to the list are the business sector and the non-governmental organizations (NGOs).

In order to facilitate a constructive set of interactions between the key actors, the government undertakes the following functions:

At macro- level

- Policy formulation and resource allocation.
- Regulatory policy-making.

At meso-level

- Financing of innovation-related activities.

- Performance of innovation-related activities.
- Human resources development and capacity building.
- Provision of infrastructure.

(DACST- White Paper 1996).

It has been stressed that the NSI is nothing but the interaction between and among science and technology partners in order to gain entry into the 'market of new and improved products and services;' (South Africa's National Research and Development Strategy-2002) this implies building a strong platform from which competitiveness can be achieved. The South African government has already made significant moves towards strengthening its science and technology system through the institutional arrangements discussed herein (for example, NACI and NSTF). However, it has been realized that given the following continuing constraints, there is a growing need to push the NSI as a national imperative and to develop a strategy to ensure its adoption. The R&D Strategy comes in as the master plan for the effective implementation of the NSI. The R&D Strategy identifies the following constraints as the main impediments to the smooth implementation of the NSI. These include:

- The governance structures in the science and technology system are extremely complex and are therefore resistant to strategic intervention by a single agent.
- The development agenda has tended to focus on the alleviation of immediate problems rather than on building platforms to deal with development in the longer term.
- The economic debate has only recently progressed beyond discussing the control of macro-economic parameters, to recognition of the importance of micro and meso-economic factors such as research, training and entrepreneurship.

(South Africa's National Research and Development Strategy-2002)

Emanating from these constraints are the following weaknesses which the R&D Strategy seek to address:

- Funding of the NSI.
- Human resources.
- Declining research and development in the private sector.
- Intellectual property.
- The fragmentation of science and technology.

The R&D Strategy set out the following technology and innovation missions in order to address the constraints and weaknesses highlighted above. These are:

- Poverty reduction (focusing on demonstration and diffusion of technologies to impact quality of life and enhance delivery).
- Key technology platforms (focus knowledge intensive new industries);
    -National Biotechnology Strategy;
    -Information and Communications Technology.
- Advanced manufacturing (linkages to the Integrated Manufacturing Strategy).
- Leveraging resource-based industries and developing new knowledge based industries from them (mobilizing the power of existing sectors).

Strategic objectives have been drawn up to turn the missions into reality:

- Enhanced innovation.
- Science, engineering and technology (SET) human resources and transformation.
- An effective government science and technology system and infrastructure.

(South Africa's National Research and Development Strategy - 2002)

In order to effect these objectives the following strategic initiatives are proposed:
The formation of the Foundation for Technological Innovation (FTI). The FTI is intended to facilitate:

- The co-ordination and financing of the new Technology and Innovation missions for South Africa.
- The integration of the players in innovation, incubation and diffusion initiatives namely the Innovation Fund, Support Programme for Industrial Innovation (SPII), Godisa programme under the Department of Science and Technology/Department of Trade and Industry and Tsumisano (the technology stations programme).
- Create and synergise innovation activities linked to universities and research organizations.
- Develop the national capacity to manage intellectual property and to strengthen initiatives for commercialisation of intellectual property.
- Establish programme for small and Black Economic Empowerment (BEE) businesses to source technology internationally when not available locally.

(South Africa's National Research and Development Strategy- 2002)

A lot of work has been done to level the ground for the proper functioning of the NSI. These include the formulation of sector policies- the Biotechnology Policy, the technology foresight exercise and the establishment of the science and technology supporting structures (NACI and NSTF). However, paramount to every activity is the financial implications. The R&D Strategy is intended to facilitate the financing of the NSI. The R&D strategy would attempt to harmonize the science and technology system and to build a research culture in all the sectors of science and technology. The NSI in South Africa does not focus on R&D as the only factor of technological change, it also looks at other 'important factors such as the ways in which available resources (including skills) are organized, at both company and firm level, and foreign sources (DACST- White Paper 1996). However, import substitution remains vital for the economies of scale, 'as locally produced innovation is preferable to an imported one on consideration of the currency in which payment is made, appropriateness of technology and comparative advantage'. (South Africa's National Research and Development Strategy-2002)

This closes my discussion of the NSI as the framework for the science and technology policy in South Africa. The next part will highlight the key policy goals.

5.4 The Key Science and Technology Policy goals

The South African science and technology policy was premised on the Growth and Development Strategy whose main aim was the promotion of economic competitiveness. The goals of the science and technology policy are driven by the science and technology vision and build within the mission statement of the science and technology executing agency- DACST. The vision of DACST is to realise the full potential of Arts, Culture, Science and Technology in social and economic development, in nurturing creativity and innovations, and in promoting the diverse heritage to our nation (DACST (2002) Strategic Plan 2002/2005). DACST in its endeavour to attain the dictates of its science and technology mission is committed to support:

- The development of science and technology expressed through the enabling mechanism of the National System of Innovation, for communities, researches, industry and government, and
- It's own transformation into a learning organization ensuring lifelong learning and accessibility to all South Africans citizen.

(DACST (2002)-Strategic Plan 2002/2005)

The vision has been translated into six national goals for science and technology development, these are:

- Improvement in the quality of life.
- Environmental sustainability.
- Competitiveness and job creation.
- Human Resources Development.
- Harnessing the Information Revolution.
- Incorporating Human Science dimension and technology.

(DACST- A study on the potential for Regional Co-operation in Science and Technology 1999)

Arising out of the broad science and technology goals are the specific science and technology Policy goals, which are stated as follows:

- The establishment of an efficient, well coordinated and integrated system of technological and social innovation;
- The development of a culture within which the advancement of knowledge is valued as an important component of national development;
- Improved support for all kinds of innovation, which is fundamental to sustainable economic growth, employment creation, equity through redress and social development.

(DACST-White Paper 1996)

The goals were set to address the urgent needs of the South African citizens, which include:

- Quality of life.
- Developing human resources.
- Working towards environmental sustainability.
- Promoting an information society.

(DACST-White Paper 1996)

The incorporation of the NSI as the guiding principle of the science and technology policy, the establishment of DACST and its cooperating partners such as National Science and Technology Forum (NSTF) and National Advisory Council on Innovation (NACI), and the research councils. The implementation strategies are elaborated in the next section.

5.5 The Science and Technology structure in South Africa.

The home of science and technology management was the Scientific Advisory Council (SAC) under the auspices of the Ministry of National Education. SAC's mandate was essentially to advise the government on science policy (IDRC: 1993). However, SAC faced a lot of challenges and criticisms.

Practically, SAC did not have a secretariat that could assist in the management issues especially key areas of science and technology such as the administration of the science vote. The membership of SAC was biased towards 'pure science interests' hence technology policy issues were not considered within the SAC' s mandate (IDRC: 1993).

SAC was also heavily criticized for the confidentiality of its activities, as the operations of SAC were not put on public records. It was argued that the high degree of confidentiality resulted in failure to assess the impact of SAC's advisory role to the government.

In the light of these challenges, the government of South Africa post 1994 opted for major shifts in science and technology management. According to (Boshoff and Mouton 2001) 'at the level of national governance, the status of science and technology was raised to cabinet level in the post- 1994 period, having existed in the apartheid years within the Department of National Education.... The elevation of S&T at national government led to the formation of three new structures, all aimed at coordinating the currently scattered government initiatives to stimulate the national innovation system'

- National Ministry of Arts, Culture, Science and Technology.
- The Ministers Committee for science and technology (MCST).
- The Department of Arts, Culture, Science and Technology.

(Boshoff and Mouton 2001: 4).

The functions and structural arrangement of these new structures are elaborated hereunder.

5.6 The functions of the S&T in South Africa.

The main function of the Ministry of Science and Technology is to formulate policies and to make decisions in the areas of Arts, Culture, Science and Technology. The Minister is also responsible for the following advisory, funding and research institutions:

- National Advisory Council on Innovation (NACI).
- National Research Foundation (NRF).

- Innovation Fund.
- National Facilities for Research.

(Boshoff and Mouton, 2001)

In order to reinforce the liaison between DACST and other government ministries, the Ministers Committee for Science and Technology (MCST) was formed. The MCST is an advisory body to the ministries or departments whose functions are of a cross cutting nature. It is "composed of all Ministers whose portfolios encompass a significant science and technology component, and is the principal policy coordinating and information dissemination body for science and technology matters across government" (DACST- White Paper on Science and Technology 1996:19).

The structure of Science and Technology at national level is illustrated by figure 5.12 on page 65.

DACST was essentially established as a secretariat to the National Ministry of Arts, Culture, and Science and Technology and serves "as the central science and technology policy formulating and coordinating body within government" (Boshoff and Mouton, 2001).

DACST has been formed to undertake the following terms of reference:

- To promote coherence and consistency in the Government's approach to stimulating South Africa's national system of innovation in general, and in its commitment to the support of science, engineering and technology development in particular;
- To promote and coordinate interdepartmental and government–wide initiatives relating to the support of innovation and technology diffusion;
- To direct the preparation of a government–wide science budget, on a multi-year basis, in order to permit Ministers to assess relative spending priorities, across the full spectrum of the Government's activities in support of innovation;
- To design and present to the Ministers a comprehensive system for the management of government SETIs, in order to ensure that their roles within the national system of innovation are clearly defined, that they

have clearly defined and understood objectives, and that they undertake their mandate with efficiency, economy and effectiveness;

- To ensure that the management system referred to above includes adequate arrangements for the evaluation of performance against international best practice, and that they undertake their mandate with government SETIs to South Africa's development;
- To represent the Government in formal international and intergovernmental negotiations dealing with science, engineering and technology and the promotion of innovation;
- To provide a link between Government and the activities of the National Advisory Council on Innovation;
- To commission or conduct any policy research necessary to the fulfilment of the responsibilities set out above.

The Main components of DACST

DACST is composed of the following five directorates, these include:

The International Science and Technology Co-operation

The International Science and Technology Cooperation has two directorates namely, the Directorate of Science and technology Cooperation (Bilateral) and the Directorate of Science and Technology Cooperation (Multilateral).

The Mission of the Directorates under International Science and Technology Co-operation is to support national objectives and priorities through proactive bilateral and multilateral engagement in the fields of science and technology. The main priorities of this directorate are:

- Leveraging international support for science and technology skills development and national science and technology initiatives;
- Benchmarking the quality of national research and development (R&D);
- Knowledge creation and dissemination; and
- Internationalising South Africa science and technology.

(DACST: Annual Report 2000/2001)

The Directorate of Science and Society

The main goal of this Directorate is to promote public awareness, appreciation, critical evaluation and understanding of science engineering and technology through systematic coherent and coordinated projects.

The Directorate of Science and Technology Coordination

The main objective of this Directorate is coordinating DACST input into interdepartmental projects, reports and high-level committees such as the Committee of Heads of Science Councils and providing a secretariat for such committees where appropriate.

5.7 Other Science and Technology structures in South Africa

5.7.1 The National Science and Technology Forum (NSTF)

In view of the cross cutting nature of science and technology, an attempt to include other stakeholders in the science and technology system was made. 'The NSTF was created in March 1995 by the Working Group Science and Technology Initiative of South Africa, and the NSTF was legally registered as an association in 1999' (Boshoff et al. 1999). The establishment of the NSTF was aimed at facilitating the inclusion of other key role players in science and technology outside the government structures so that an 'integrated approach to science and technology' (Boshoff et al. 1999) could be achieved.

The NSTF stands as 'the sounding board (of science and technology stakeholders), communications channel and constructive watch dog of Science and Technology at implementation level' (Boshoff et al., 2000).

The mission of the NSTF is to "*contribute towards national reconstruction and towards the economic, human and social development needs of SA bearing in mind our environmental needs*" (http:// www.nstf.org.za) (16 September, 2002).

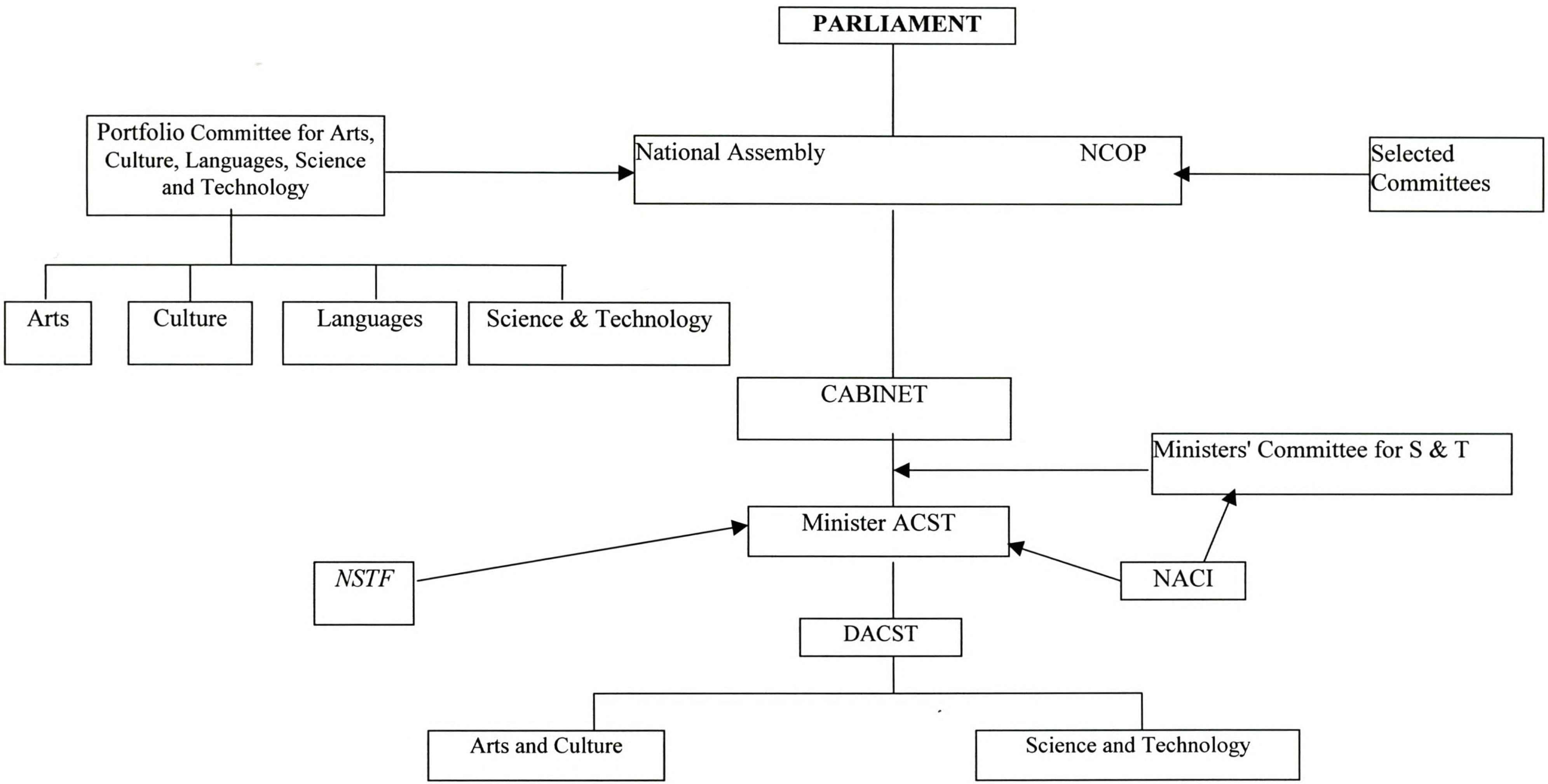


Figure 5.12 Structure of Science and Technology at National level

(Adapted from Boshoff et al., 1999)

The NSTF is composed of science and technology stakeholders from diverse range of sectors namely:

- Science councils (individual councils, CHSC).
- Education sector (universities, technikons, CUP, CTP).
- Government Departments (Education, Agriculture, DACST amongst others.
- State Corporation and Utilities.
- Organizations of civil society (for example, community organizations).
- Labour.
- Professional Associations.
- Business Sector.

(Boshoff et al., 1999)

The structure of the NSTF can be illustrated as follows:

The *Plenary* which consists of all the NSTF representatives and its functions are:

- To agree on the framework of values for the activities of the NSTF.
- To discuss matters relating to its mission and objectives (and to refer areas for further discussion and or/study to the Working Group and Task Groups), and to monitor progress towards these objectives.
- To discuss proposals made by the Working Groups.

The *Working Group* is the subset of the plenary set up to investigate S&T related areas deemed important by the plenary.

The *Secretariat*, *Chairperson* and *Chief Executive Officer*.

(http:// www.nstf.org.za September 2002)

The NSTF has made some contributions to the development of the science and technology policy and other related policies, these include:

- White Paper on science and technology.
- Foresight Exercises.
- Discussion Paper on the Management of science and technology (for DACST)
- Draft Declaration on Science and the use of Scientific Knowledge.
- Draft Science Agenda Framework for Action.
- National Health Technology Policy (for Department of Health).

(Boshoff et al., 1999)

5.7.2 National Advisory Council on Innovation (NACI)

In order to facilitate the implementation of the NSI, the Government of South Africa created NACI as a statutory body in 1997. NACI is mandated to advise the Minister- Arts, Culture, Science and Technology (ACST) and the Ministers' Committee for science and technology on ways in which, science, mathematics innovation and technology (including indigenous technologies), may contribute towards achieving set goals. NACI as an Advisory body basically to advise the Government on:

- Technical aspects and policy matters on science and technology.
- Research priorities.
- Commercialisation of research results.
- Human resources development in science and technology fields.
- Infrastructure support.
- Financing.

NACI in its role of providing advice on policy and funding has introduced some major changes in the allocation of funds. The most significant move has been that funding now consists of the core funding through a Parliamentary grant, and the second component is allocated through competitive bidding process from the Innovation fund. The Innovation Fund focuses on the major themes of competitiveness, quality of life and environmental sustainability.

5.8 Conclusion

It is obvious from all the efforts made that S & T in South Africa is accorded high priority. This is indicated by the adoption of the NSI as a guiding principle towards the achievement of the S & T overall goals. Science and technology are considered to be central to creating wealth and improving the quality of life in contemporary society. In order to facilitate this function it is accepted that Government has a prime responsibility to create an enabling policy environment in terms of regulatory and funding mechanism. The NSI has been adopted to operate within the overall framework of the Reconstruction and Development Programme (RDP) and the Growth and Development Strategy (GDS). The Structure of science and technology in South Africa is fairly broad and covers all the key players in science and technology, for example, the establishment of NSTF and NACI as advisory bodies at different levels facilitate the implementation of NSI. The question is whether the NSI is making a significant impact on the private and industrial sector given the high level of technologies acquired from abroad.

Chapter 6. Discussion and Conclusions

Science and technology are seen as the universal modes of economic growth hence the growing appreciation of the role of science and technology in economic development and its integration into theoretical approaches in the fields of economics and public policy. However, "...Bringing scientific knowledge and technological learning to the core economic policy may be the most critical challenge facing African countries" (Juma C. 2000). There are other problems, which can be highlighted as common to most African countries. These include as set out by (Juma C. 2000), the lack of patience and understanding that technological innovation is a long-term process, which does not show immediate results. This requires that technology policies are part of a long-term development vision. In many cases, this long –term vision may need to be part of the political process and be based on a certain degree of consensus. Without political consensus, science and technology policies and strategies may not hold out long enough to show results.

It appears that in all the three countries science and technology development has been hampered by state politics. In the case of both South Africa and Namibia, politics of racial domination contributed to the fragmentation of the science and technology system. Science and technology were viewed as an elitist and scholarly business; it was not a national priority.

Malawi has been a one party state for a long time yet it adopted a pluralistic approach of science and technology management in which the decision making is based on a lot of compromises for consensus building. Although NRCM was established as the overseer of science and technology activities in Malawi, progress could not be made because decisions on science and technology matters were taken independently by the sectors without any formal consultation with the NCRM. This method of administration jeopardized the science and technology activities in most of the science and technology oriented sectors.

Khalil-Timamy (2002) outlined the major weaknesses that inhibit the development of S&T. The following are some of the factors contributing to the weaknesses found to be existing among the three countries.

- Poorly disposed and rationalized institutional structures to promote technological development (the pluralistic approach taken by Malawi).

- Ineffective planning, disseminating and co-ordinating functions of research institutions (Malawi through the NRCM).
- Ineffective policy framework to actively guide and influence the evolution of robust competence (this was the case in South Africa before 1994 and Malawi before the new Science and Technology policy was formulated).
- Lack of a comprehensive set science and technological indicators to guide action and monitor progress (Malawi and Namibia)
- Poor utilization of R & D results (Malawi and Namibia)

Traditionally, as indicated by (Derek de Solla Price et. al., 1977), "whatever the institutional arrangements, the organizations concerned with science policy, wherever they are, all fulfil at least three functions: Information, Consultation, and Co-ordination. Science policy of any kind needs to be prepared by administrative services, clarified by the advice experts, discussed by inter-ministerial committees at the highest level, and finally, of course, decided upon and implemented." The three countries discussed earlier followed the same path as indicated by Derek de Solla Price et al. (eds) (1977), and in addition, they have established directorates of technology transfer and policy planning. The South African structure is much broader as it includes the directorates of Public Science and International Liaison (to facilitate the external linkages and the promotion of public understanding of science, Engineering and technology).

The three countries discussed in the thesis have their Science and Technology management geared towards the NSI for the improvement of the quality of life for their citizens. One of the main commonalities in the analysis of the three countries is the nature of the relationships between state and market. That is, the relationships within the NSI follow the demand-pull model elaborated on pages 18-19. As put by Scerri (2001) on the one hand, "national innovation systems can be, to different degrees, the product of conscious, goals driven, policy initiatives at the macro level. On the other hand, they are determined by the reactions to and the result of such policies. The results of these policies are therefore, at least partially driven by limited micro, or sectoral imperatives." The major differences are the operational mechanisms. For instance, in the case of South Africa, the NSI efforts converge towards wealth creation and quality of life through technical progress, in Namibia the NSI focuses on trade and industry through an improved science and technology education while Malawi also follows the enterprise development path. The South African – NSI hinges on all of the four categories mentioned by Freeman and Perez (1988) (see page16) where the incremental innovation model is often followed by the informal sector. The radical innovations model is the most preferred model and it is adopted in South Africa because the R&D infrastructure is well established and the government has also embarked on the R&D strategy. Malawi and Namibia also wish to follow the incremental innovation approach, due to their weak R&D infrastructure and the weak private sector compared to South Africa, both countries' NSI are based on the incremental approach.

In generic terms the S&T development path in the three countries can be summarized as follows:

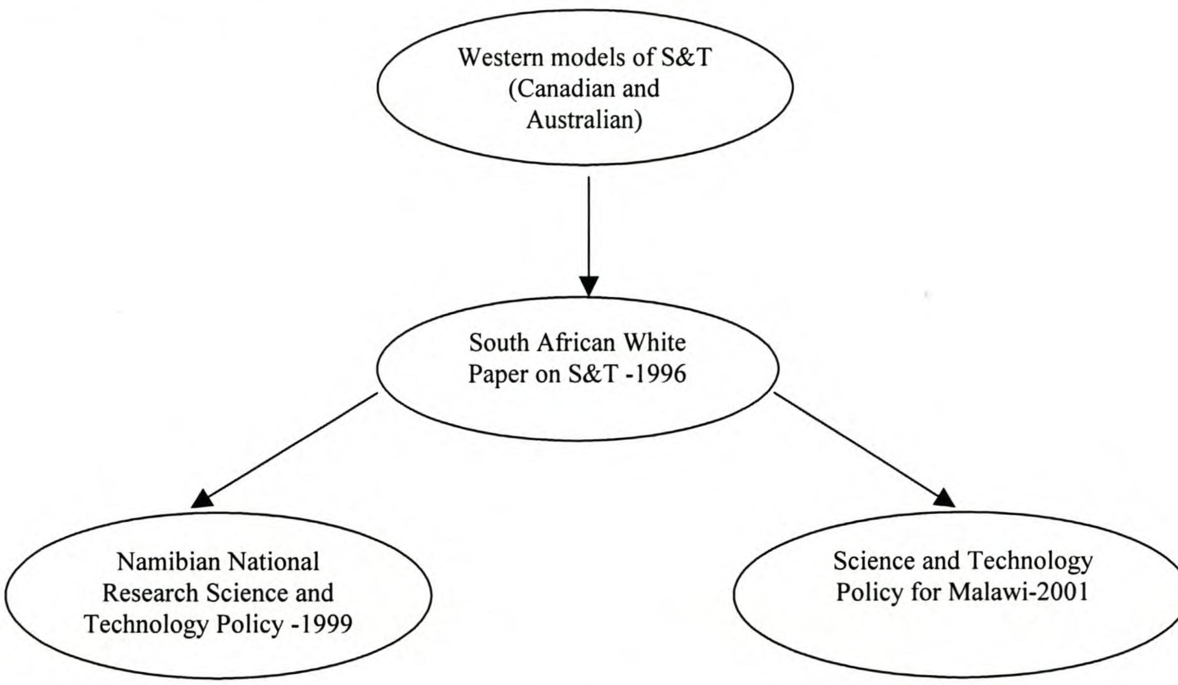


Figure 6.13 The Trend of S&T development models in Malawi, Namibia and South Africa.

Learning from the experiences of these three countries, one can conclude that that the South African model had a direct influence on the development of science and technology policy in the other two countries. The advent of the democratic rule in South Africa made it possible for the government to engage the international organisation such as the IDRC and to undertake comparative studies of other countries for example, Canada and Australia from which they were able to tailor their S&T model.

It has been observed at the level of measurement the evaluation mechanisms of the NSI are not clearly spelled out in the other two countries, namely, Malawi and Namibia. In the case of

South Africa, NACI appears to be well established and carries its innovation strategy well. This is exemplified by annual reports (*The South African Science and Technology Key facts and figures 2002*) on the indicators of science and technology that provide data on the performance of the key stakeholders in the NSI. It is essential for science and technology performers to set up the ways in which they can measure the efficiency[22] of their national systems of innovation. This means, it is necessary to undertake inventories of their R&D institutions so that the active and the dormant ones could be identified; To establish the output viz. the expenditure on R&D in order to determine the cost effectiveness and to show the distribution and ownership of the innovation centres so that the coverage of the NSI is indicated. It is therefore, important for countries to take stock of what is on the ground in science and technology (science and technology audit and situation analysis) so as to inform their policies and to establish the strengths and weaknesses and to identify the niche areas for science and technology development. These types of baseline data allow the governments to arrange their structures through informed decision-making. South Africa has undertaken a series of studies to determine their state of technological development and needs through the *Technology Foresight* Exercise. The data from these studies go a long way towards recommending policy reforms, assist countries to set benchmarks in technology development and to a large extent indicate the contributions of science and technology to national development.

Two countries (Namibia and South Africa) have established a system of incentives for the promotion of innovations. In Namibia the Fund for Innovation in Science and Technology (FIST) is administered by the Foundation for Research, Science and Technology. South Africa, the innovation fund is administered by NACI while in Malawi intends to establish a fund through an Act of Parliament. All three countries have committees of science and technology, which indicate the high level of commitment to the development of science and technology.

Given the current trends in economic competitiveness, there is need to establish a systematic and long-term institutional basis for building capacity in science and technology policy analysis to be able to effect policy adjustments and institutions in the light of global changes and new opportunities. The science and technology policy developments in the three countries concur

[22] Efficiency refers to the transformation of existing resources of a country into successful innovation (J. Niosi et. al 1993).

with my hypothesis that most of Southern African countries engage in a national system of innovation in their science and technology management in order to accomplish economic competitiveness.

A careful long-term science and technology policy is a precondition to build up a sound institutional framework and to enter the race of science and technology development. Such innovation capacity, however, embodies functioning linkages between public and private sector institutions for R & D generation and effective diffusion at all levels of society. In concrete terms, this also means that developing countries do not have to focus on building scientific communities, which do not only include science and research institutions, but also need to encourage the application and implementation of generated knowledge within the institutions.

In addition, to cope with the pace of technological development, continuous strengthening of human resources is imperative. However, governments especially those in the developing and least developed countries, should be careful about acceptance of the kind of cooperative arrangements made with multinational and assume responsibility as mediator in setting up linkages between different institutions in the country.

7 Footnotes

7.1 Problems encountered during data collection

The thesis has been an eye-opener indeed, as I learned the processes through which most countries developed their science and technology systems, and their current status in S&T management. However, the process of data collection has been characterised by joy and pain. The exciting part has been the extension of my knowledge in the area and my contribution to science and technology written material. The painful part has been the delays encountered in receiving documents from the contact persons in the countries of reference. The other major setback is availability of written information on other countries used as case studies in the thesis namely, Malawi and Namibia. This limits the scope of research in these countries and hence resulted in methodological problems. I had intended to complement the missing data with telephone interviews, but it appeared that the calibre of target population for interviews was another hindrance as I was supposed to interview people at policy making level (that is, Principal Secretaries/Director Generals). These people's schedules are always extremely full and they cannot allocate time for academic interviews.

7.2 Lessons learned

Documentary research is important in as far as building and compiling the works of previous writers, but the disadvantage is that some information may be outdated especially in the case of official documents. By this, I mean the current state of affairs may not be known due to poor documentation and unavailability of up-to-date reports. The greatest lesson I have learned during the process of my research is that time is the essence of life.

References

Addison G. (2000). *The Hidden Edge: South Africa's Quest for innovation.* Yeoville, South Africa: The Engineering Association.

Babbie, E. et. al (2001). *The Practice of Social Research* Oxford University Press Southern Africa: Cape Town, South Africa.

Boshoff et al. (1999). *Science in South Africa History, Institutions & Statistics Vol.1.* Stellenbosch: Centre for Interdisciplinary Studies, University of Stellenbosch.

Boshoff, S.C. and Mouton, J. (2001). *Science in Southern Africa in Transition.* Stellenbosch: Centre for Interdisciplinary Studies, University of Stellenbosch.

Brandt Commission. (1980). *North-South: A Programme for Survival.* London: Pan Books.

DACST. (1994). *Green Paper. On Science and Technology: Preparing for the 21st century.* Pretoria: Department of Arts, Culture, Science and Technology.

DACST. (1996). *White Paper on Science and Technology: Preparing for the 21st century.*

DACST. (2000). *A Study on the Potential for Regional Co-operation in Science and technology*. Pretoria: Department of Arts, Culture, Science and Technology.

DACST. (2001). Annual Report 2000/2001. Pretoria: Department of Arts, Culture, Science and Technology.

DACST. (2002). Strategic Plan 1 April 2002- 31 March 2005.

De Solla Price, D. et al. (1977). *Science, Technology and Society:* A Cross- Disciplinary Perspective. London: Sage.

Derksen L., and Gartrell, J., (1992). Scientific explanation. In *Encyclopaedia of Sociology*, Vol.4, pp.1711-1720. New York: Macmillan. In Neuman W.L 1997:66).

Directorate of Research, Science and Technology. (1999). *National Policy on Research, Science and Technology*. Windhoek, Namibia : Printech cc.

Diyamett B. et al. (2001). *Innovation Indicators within Sub-Saharan Africa; Usefulness, Methodologies and approaches. A specific case for Tanzania.* Paper presented at DACST/OECD Seminar on Innovation measurement in OECD and NON OECD countries 28-29 March 2001, Pretoria, South Africa.

Edquist C. (ed.) (1997). System of Innovation –Technologies Institutions and Organisation. London: Pinter Publishers.

Freeman C. (1988). Japan: A New System of Innovation? In G. Dosi et al. (Eds), *Technical Change and Economic Theory*. London: Pinter Publishers

Freeman C. (1987). Technology Policy and Economic Performance. London: Pinter Publishers.

Glaser and Strauss, (1967:17-18). In Thomas D. Cook et al. (Eds), *Qualitative and Quantitative Methods in Evaluation Research.* USA: Sage Publications.

Government of Malawi, (June 2002) *Malawi Science and Technology Policy*, Lilongwe, Malawi.

Government of South Africa (2002). *South Africa's National Research and Development Strategy.*

Government of Namibia. (May 1999). *National Policy on Research, Science & Technology.* Directorate of Research, Science & Technology. Windhoek, Namibia.

Hamel J. (2000). *Science and Technology for Sustainable Development in Africa: Guidelines for Effective Policies.* Paper presented at the Lesotho National Science and Technology Policy Formulation Workshop, February 2000.

http://www.nstf.org.za. September16, 2002.

IDRC. (1993). Towards *a Science and Technology Policy for a Democratic South Africa.* Mission Report, July 1993.

Ihde D. (1983). The Historical-Ontological priority of technology over science (pp: 240-241) in Paul T. Durbin and Friedrich Rapp (eds.), *Philosophy and Technology*.235-252

Juma, C., (2000). *Science, Technology and Economic Growth: Africa's Biopolicy Agenda in the 21st Century*. Tokyo, Japan: Omega Communications Inc.

Khalil-Timamy. M. H. (2002). state of Science and Technological capacity in Sub-Saharan Africa. Special series No.12, African Technology Policy Studies Network (ATPS)., Nairobi, Kenya.

Lall, S. (1987). Technological Capabilities and Industrialization: World Development, 20(2) pp 165-86.

Loxton (1992:135) Criteria for Determining the Functions and Organizations of Central Government administration in South Africa. In J. S. Wessels, *Report Pan, 4A.* Pretoria: Human Sciences Research Council.

Lundvall, B. A., (1988) Innovations as an Interactive Process: From Producer user- production Interaction to the National system of Innovation. In G. Dosi et. al (eds), *Technical Change and Economic Theory.* London: Pinter Publishers.

Marais, H.C. (2000). *Perspectives on Science Policy in South Africa.* Menlo Park, South Africa: Network Publishers.

Marglin, F.N. and Marlin, S.A. (Eds). (1990). *Dominating Knowledge; Development, Culture and Resistance*. Oxford: Claredon Press.

Mouton J. (1996). *Understanding Social Research.* Pretoria: J.L. Van Schaik Publishers.

Neuman, W.L. (1997). *Social Research Methods: Qualitative and Quantitative Approaches.* Boston, USA: Allyn and Bacon.

Niosi, J. et al. (1993). National Systems of Innovation: In search of a workable concept. *Technology and Society,* 15:207-227.

Oyelaran-Oyeyinka, B. (1998). Technological Capability Acquisition: Technological Transfer and Technological Learning. Lecture delivered at the FEDEN Training Seminar on " Technological Options for Nigeria's Sustainable Development." Nigeria.

Phiri, I.M.G. (1999:4). *Overview of the S&T System and Policy in Malawi*; Science and Technology in the SADC region for the 21st Century. In DACST, Proceedings of a Meeting of Directors- General/ Heads of Science and Technology in the SADC Region. Roode Vallei, Pretoria, South Africa. 20-21 April 1999.

Phiri, I.M.G. (2000). *Overview of S&T system in Malawi*. In DACST, *A Study on the Potential for Regional Co-operation on Science and Technology.* (pp. 46) Pretoria: Department of Arts, Culture, Science and Technology.

Rogers, E.M. (1983). *Diffusion of Innovations*. New York, USA: The Free Press.

Rosenberg N. (1982). *Inside the Black Box: Technology and Economics.* London: Cambridge University Press.

Rubin H. J., and Rubin I.S., (1995). *Qualitative Interviewing; The art of Hearing Data.* California, USA, Sage Publications.

Salomon J. (1977). Science policy studies and the Development of science policy. In *Science, Technology and Society: A cross – Disciplinary perspective*. Derek se Solla Price et al., (eds): 43-70 London, Sage Publications.

Scerri, M. (1995) Towards a Science and Technology Policy for South African. *Development in Southern Africa.* 12(1): 49-62.

Scerri, M. (2001). *The Conceptual Fluidity of National Innovation Systesm – Implications for Innovation Measures.* Paper presented at DACST/OECD Seminar "Innovation measurement in OECD and NON OECD Countries", 28-29 March 2001, Pretoria, South Africa.

UNIDO. (1996). *Industrial Development Global Report.* Oxford: Oxford University Press.

Van Kent A., (1999:4). *Overview of the S&T System of Namibia*; Science and Technology in the SADC region for the 21st Century. In DACST, Proceedings of a Meeting of Directors- General/ Heads of Science and Technology in the SADC Region. Rhoode Vallei, Pretoria, South Africa, 20-21 April 1999.

Wrightsman, S. et al. (1976). *Research Methods in Social Relations*. Tokyo, Japan: Holt, Rinehart and Winston Inc.