Republic of Mozambique

Council of Ministers

Mozambique Science, Technology and Innovation Strategy (MOSTIS)

Time Horizon: 10 years

Approved by the Council of Ministers in the 15th Regular Session on 27th June 2006

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His Excellency Armando Emilio Guebuza
President of the Republic of Mozambique

OPTIMIZING RESOURCE EXPLOITATION
A leverage to drive our development

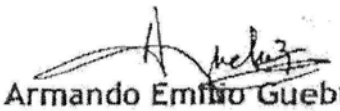
This Indian Ocean Pearl is endowed with abundant resources with a huge potential to stimulate our progress towards the welfare we have been pursuing since 1962. However, most such resources remain either unexploited or, when exploited, it is not to their fullness and magnitude. In the face of these shortfalls, poverty gathers strength to continue to ravage relentlessly the Mozambicans from the Rovuma River to Maputo River and from the Indian Ocean to the Zumbo District.

Optimizing the exploitation of these resources and their sustainable use can contribute to reverse this scenario, thus weakening the current foundations of poverty. In this regard, scientific research, innovation, technology development and transfer, coupled with the tapping on the ancient local knowledge have a relevant role to play towards our National Agenda for the Fight against Poverty. They can act as leverages for the creation of more jobs, for increased production and productivity and for the full exploitation of our resources, in order to, at least, reduce present day wastage. These endeavours will result in a greater food security, enhanced and more diversified national products for both domestic consumption and for export, and they will drive the emergence of further national entrepreneurs.

The Information and Communication Technologies also play a fundamental role in our National Agenda. They constitute vital tools for the dissemination and expansion of education, health and other knowledge to more Mozambicans, regardless of their geographical location. They also constitute a way of streamlining and rendering communication viable, as a useful tool that will bring the citizens closer to the services they need, create a conducive environment for production and businesses, and for the strengthening of good governance, at all levels.

Science, Technology and Innovation, therefore, become the engine for sustainable production and development and for both improved services and improved quality of life for the Mozambicans. Therefore, we have defined the Strategy for Science, Technology and Innovation in our Beloved Homeland, for the next 10 years, as the driving force for finding solutions to the problems that hinder the full exploitation of our resources and their subsequent deployment to the front line of the fight against poverty.

We urge all Mozambicans to live up to this challenge with increased responsibility. Our natural resources, together with the huge human potential, the wisdom and courage we always shown to have, are assurances of our ability to defeat poverty and build well-being for the wonderful Mozambican People. Scientists should renew, day after day, their commitment of embrace self-esteem as their motto, their self-improvement as the medium and their masterpieces as the end-products towards the materialization of our collective aspiration of a prosperous, more united and forever peaceful Mozambique.



Armando Emílio Guebuza

(Presidente da República)

Introduction to the MOSTIS by the Honourable Minister of Science and Technology

The challenge has been issued. The Government of Mozambique has approved in June 2006, in a Cabinet Session, Mozambique's Science, Technology and Innovation Strategy.

The approval of this instrument constitutes a clear signal of the relevance and commitment of the Government towards Science and Technology, to be materialized through its pillars: Scientific Research and Innovation, Technology Development and Transfer, and Information and Communication Technologies.

The strategy development process entailed a widespread consultation and opinion gathering process throughout the country, with the participation of the major stakeholders, resulting in the identification of the strategic areas on which Mozambique should focus to achieve greater competitive edge. We are convinced that direct and focused investment in the nine strategic areas, coupled with the five cross-cutting areas and the two enabling technologies also identified in the strategy, will result in the country's tangible development in a relatively short period of time and in a higher GDP. Obviously that this investment should be based on the research parameters already set for each area, with unequivocal priority given to the research and technological programmes and projects of a multi-disciplinary nature.

The implementation of the strategy should be facilitated through the correct use of the tools and mechanisms established in the National Science and Technology System, namely: the National Research Fund, the Status of the Scientific Researcher, the Regulation on the Mobility of Scientists and the different coordination mechanisms the annual planning meetings and biannual meetings with the cooperating partners

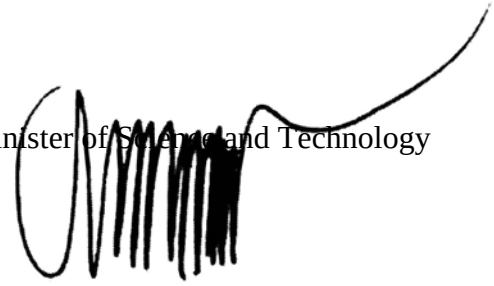
Equitable access to Science and Technology is a constitutional right of all Mozambicans regardless of their geographical location. Thus, we ought to improve our mechanisms for spreading and disseminating Science and Technology, the findings of

scientific research and for technology transfer. We indeed should transform the Regional Science and Technology Centres, the Provincial and District Nuclei of Science and Technology into models of linkages between the generation of scientific knowledge and its use by those who need to benefit from it most.

The way ahead requires from all of us and from the scientific community in particular, a changed mindset in terms of their work and the impact it has on the country's development. Obviously that this changed mindset should be accompanied by a strict reform process of our current Science and Technology System where the establishment of common use or open facilities and infrastructures for should play a strategic role.

Thus, we invite the scientific and technical community from our country to capitalise on this unique opportunity of transforming our knowledge and energy into tools to fight poverty and foster Mozambique's development. Time has come for the national community to benefit proactively from the advantages brought about by Science and Technology, through entrepreneurship, creation of job opportunities and wealth.

Let us, therefore, transform Science, Technology and Innovation into the primary sustainable production and development force in Mozambique.



The Minister of Science and Technology

Prof. Dr. Eng.º Venâncio Simão Massingue

Executive Summary

The goal of Mozambique's Science, Technology and Innovation Strategy (MOSTIS) is to establish an enabling framework, including strategic objectives and programmes, that enables science, technology and innovation (STI) to be harnessed, thereby enhancing their contribution to poverty reduction, to economic growth and to the social wellbeing of Mozambique's citizens. The vision for STI is:

> *The ubiquitous and equitable availability and use of Science, Technology, Innovation and ICTs as a right of all Mozambicans, in order to accelerate poverty eradication, wealth creation and the improvement of their social well being.*

The scarcity of resources demands that science and technology activities be directed to areas and sectors with the largest potential impact (direct and indirect) on poverty reduction, wealth creation and improvement of social wellbeing. Therefore the Mission is:

> *To promote the supply of scientific and technological solutions to priority sectors defined in the Government's five year programme (2005-2009), PARPA, Agenda 2025, and other national development programmes, aiming at improvement in the quality of life of Mozambican society.*

Following an analysis of the strengths and weaknesses of the Mozambican economy and society, and of Mozambican science and technology, the potential threats that must be faced along with the opportunities and challenges that exist, several strategic areas were identified to serve as the strategic focus of the MOSTIS, for the development of the country as a whole. In addition, in the context of a vision for sustained and harmonised development, strategic crosscutting issues were identified. These crosscutting issues have the potential to impact, directly or indirectly, on the dynamics of the strategic areas, and by addressing them, progress in each strategic area may be boosted. The strategic areas include:

- Human Resource Development; Agriculture; Education; Health; Energy; Marine Sciences and Fishing; Construction; Water; and Mineral Resources,

The sustainable development of these strategic areas will only be achieved provided the following strategic crosscutting issues are addressed in parallel:

- Social and Human Sciences and Culture; Environmental sustainability; Ethno-botany; Gender equity; HIV/AIDS;

In addition, the approach of the strategy is to harness the potential of enabling and crosscutting technologies such as:

- ICTs and Biotechnology.

The implementation of this strategy calls for the strengthening of the national S&T system, including its component institutions and their linkages, and for research efforts that are directed at economic development and at reducing poverty. The development of human resources with the necessary S&T skills is an essential ingredient in the improvement of the national S&T system. A culture of innovation must be nurtured amongst Mozambican society at all levels, which instils an entrepreneurial attitude for dealing with both social and economic challenges alike. In particular, those caught in poverty must be enabled to address their challenges using relevant, science-based knowledge and approaches that exploit their inherent ability to develop innovative solutions.

It is also important to define the roles of the different Mozambican players so that they collaborate in a coherent way, and to ensure that their yearly plans mirror substantially the approved strategic programmes. MCT will play a coordinating role in the implementation of this strategy, as well as in monitoring the implementation of all activities in order to ensure that the defined goals are achieved. For this, strong links should exist between research institutions and other public institutions to enable MCT to play its lead role.

The time horizon for implementation of this strategy is ten years. With a view to evaluating the outputs, the programmes established or to be established to implement this strategy are considered to be of short, medium or long term duration, corresponding to three, six and ten years, respectively. The strategy has a dynamic character and will be subject to review every three years, for which stakeholders in different sectors and in society should play an active role.

The ambitions of the strategy are wholly consistent with the Government's five year plan, with PARPA II and with Agenda 2025, and may be summarised under the following strategic objectives:

1 – Foster a culture of innovation throughout Mozambican society. The development of a culture of innovation, founded on science and technology, is key to enabling people, at all levels, to use their natural talents to address their own needs, thereby taking responsibility for their own development, and to enable them to participate productively in the global economy.

2 – Promote grass-roots innovation and the use of S&T-based approaches by poor and disadvantaged communities. The power of innovation, based on scientific and technological approaches, is a key to enabling those caught in poverty to improve their quality of life. However, it must be recognised that little is known about promoting grass-roots innovation, and therefore efforts in this area will be breaking new ground.

3 – Promote R&D and innovation within the public and private sectors. The development of new products and services will promote economic development and the creation of wealth. Therefore innovation, including research and development, product prototyping and commercialisation, should be promoted particularly amongst indigenous small and medium enterprises (SMEs) as well as amongst large industry.

4 – Promote the transfer of technology. The transfer of technology is important at two levels. With respect to technologies that have been developed outside of Mozambique, it is important for Mozambique to enhance its ability to adapt and adopt such technologies in order to harness them in service of national priorities. In addition, mechanisms for the transfer of technology at a local level will provide opportunities for individuals and communities to improve their quality of life through sustainable livelihoods. Technology transfer should always be understood to include both the tangible technology, as well as the knowledge and expertise required to adapt and maintain the technology, and to enhance it where applicable.

5 – Promote the use of ICT for good governance and service delivery, and for the diffusion of knowledge, in support of poverty reduction and economic growth. ICTs are universally acknowledged as being the driving force of the global Information Society and of a knowledge-based economy, as well as being an engine to promote the rapid and sustainable growth of developing countries. Government should harness them

to bring public services to all citizens, and to stimulate the diffusion and absorption of knowledge for poverty reduction and economic growth.

6 – Promote human resource development at all levels in the areas of science, technology and innovation. Developing human resources in the area of S&T is a key enabler of innovation for socio-economic development in a globalised world, and for building the capacity to harness S&T to address poverty. In order to create the needed S&T human resources, education and training are required, as is a working environment with the right reward mechanisms and incentives so that S&T practitioners experience their role as being valued, thus securing their maximum contribution.

7 – Build and improve the policy instruments, institutions and infrastructure of the S&T system. An improved effectiveness and efficiency is needed of the components of Mozambique's system of science and technology, as well as of the system as a whole, to ensure that it contributes optimally to the country's development goals. This will involve the addition of capabilities, capacities and infrastructure, a review, and possible restructuring, of the components of the system of S&T, and the greater alignment of the outputs, outcomes and impacts of the system with national development priorities. In particular, the system must be made more effective and efficient in contributing to the goal of poverty reduction, while also fostering economic development.

8 – Establish funding policies and mechanisms for research and innovation. Carefully crafted funding policies and instruments, with coordinating and accountability mechanisms, will ensure an optimal focus of research efforts on national development priorities.

9 – Review, evaluate and enhance the performance of the S&T system. Mozambique's S&T strategy is being established and implemented. It is crucial to devote time and resources to assessing the performance of the policies, interventions, structures and mechanisms that have been implemented so that any necessary adjustments and enhancements may be made, in a judicious and timely fashion.

10 – Promote the mainstreaming of S&T within all sectors. The potential of S&T to contribute to poverty reduction and economic growth will be unleashed only by mainstreaming it within each sector.

The Ministry of Science and Technology (MCT) is a central organ of the Government that, in accordance with the principles, aims, policies and plans defined by the Government, determines, regulates, plans, coordinates, develops, monitors and evaluates the activities dealing with science and technology. MCT will therefore lead the research efforts and will support and coordinate the activities of all role-players and stakeholders, both public and private, as they implement the strategy. In addition, MCT will develop and implement a monitoring and evaluation framework, including benchmarks and performance indicators, to support the effective achievement of the strategic objectives.

Preface

This strategy document presents a vision for science, technology and innovation (STI) for Mozambique. It identifies a number of strategic areas, including strategic crosscutting areas, and also enabling technologies, with associated research lines and programmes, and in addition it establishes a set of strategic objectives and programmes, to assist stakeholders and partners in defining appropriate actions to realise the potential role of STI in poverty reduction, in wealth creation, and in the improvement of the social well being of Mozambicans.

The important role that science and technology have to play in this regard stimulated the Government of Mozambique to establish the Ministry of Higher Education, Science and Technology in 2000, and then in June 2003 the Council of Ministers approved a Science and Technology Policy that represents the foundational policy statement for this area. It has four policy thrusts: Research (knowledge production); Education (foundations of scientific knowledge and learning culture critical for technological innovation); Innovation (based on creative capacity for creation, use and adaptation by economic agents), and Diffusion (provides society access to knowledge and technology and fuels creativity and innovation).

On 4th February 2005 the Ministry of Science and Technology (MCT) came into existence through the Presidential Decree Nr.13/2005, conferring a major role to science and technology. This priority is reflected in the Government's *5 Year Plan* which deals explicitly with science, technology, innovation, and information and communication technologies. The Plan recognises the current global technology revolution based on the domination and use of science, and so it emphasises the need to inculcate scientific culture into society, people and institutions through their direct participation in the production, dissemination and use of knowledge.

In response to the national imperatives expressed in the above-mentioned Policy and Plan a concept document entitled *Science and Technology Challenges and Opportunities* was produced by MCT in March 2005. This concept document outlined the main concerns and approach of MCT for fulfilling its mandate, and it set the scene for this exercise to develop a science, technology and innovation strategy for Mozambique.

The development of such a national strategy is necessarily a time-consuming process: it is important to generate trust and buy-in, and to promote a convergence of interests and visions among the stakeholders, so as to build further consensus and credibility concerning any applicable institutional and governance arrangements. In this regard, the present document has benefited substantially from significant consultation with a range of stakeholders, and the public nationwide, which served to provide the inputs and insights needed to formulate this strategy.

The Document Structure

The document is structured as follows:

Introduction: which explains the context and background of the strategy, and sets out the vision and mission, and the development challenges for S&T.

Science, Technology, Innovation and Knowledge: which reviews existing policies related to STI and the relevant institutional and human resources in the context of the emerging knowledge economy. Describes the growing awareness that S&T has a fundamental role to play not only in economic development, but also in poverty alleviation and improving the quality of life for all.

Strategic Framework and Strategic Areas: which sets out a framework for high priority action through three action fronts, namely: (a) applied and adaptive research and development for the economic and social well-being of the population; (b) research that is relevant to and improves education, as well as for technology transfer and innovation; (c) frontier research, that fosters national interests and a national competitive edge. A framework of several strategic factors is then described, followed by the list of strategic areas, including strategic crosscutting areas, and enabling and crosscutting technologies that have been identified for Mozambican development through STI.

Strategic Areas: which provides strategic direction for the strategic areas, through identifying strategic issues and research lines.

Strategic Crosscutting Areas: which discusses the gaps and challenges, and the priorities for the strategic crosscutting areas.

Enabling and Crosscutting Technologies: which discussed the challenges and contributions associated with ICTs and biotechnology as driving forces for S&T development.

Creating a Culture of Innovation: which provides an overview of the current status of innovation in Mozambique, and discussed strategic issues related to creating a national culture of innovation.

The National S&T System: which reviews existing polices related to S&T, the relevant institutional and human resources, the relationship and roles of the public and private sectors, and discusses the challenges and priorities.

Funding the S&T System: which discusses the funding requirements for S&T, the challenges that must be faced, and sets out proposed solutions, including the formation of a National Research Fund for funding STI through various funding instruments.

Strategic Objectives and Programmes: which sets out the strategic objectives of the MOSTIS, and their related programmes for implementing the strategy.

Implementation: which indicates the issues that must be addressed to ensure a successful implementation of the strategy.

Appendices: The first appendix provides a glossary of some key concepts used in the strategy. The second appendix lists the public research institutes in Mozambique. The remaining appendices set out the research lines and example programmes for the strategic areas, strategic crosscutting areas and enabling technologies.

1 Introduction

1.1 Background

In the last a decade Mozambique has achieved sustained economic growth and reduction in poverty levels in the context of a stable political and economic system and environment. Mozambique is moving from being a stagnant laggard among the least developed countries to becoming a trendsetter in the fight against poverty and in economic development.

The macroeconomic performance of Mozambique has been impressive. Mozambique, and a group of seven other low-income African nations, posted an average annual growth of 2.9% in per capita income over the past decade. Real GDP growth since 1993 averaged 8.1%, but decreased to 7.1% in 2003, primarily due to the floods of 2000. GDP growth is projected to be 7.7% for 2005. However, most of this growth can be attributed to a few mega-projects, such as the Mozal aluminium smelter and the Sasol gas project. Very little impact has been felt by the wider economy, particularly the small and medium enterprise (SME) sector, which has the potential of becoming the dominant engine of sustainable economic growth, as there are few linkages between the mega-projects and the SMEs. A consequence of this imbalance is that most of the foreign direct investment into Mozambique is going into the mega-projects, with very little being used to stimulate the broader economy.

On the positive side, in the period 1993 – 2003 Mozambique achieved the largest percentage reduction in poverty among African nations, from a record high of 69% down to 54%. In spite of its relatively high population growth, Mozambique's per capita income places it in the first tier of fastest growing African countries. Budgetary spending on education has increased over the years to reach 5.1% of GDP in 2004, and literacy rates have grown from 22% in 1992 to 49% in 2004. The state budget for the main public university, Universidade Eduardo Mondlane (UEM), the alma mater of Mozambique, has experienced continued growth over the past few years.

The trade imbalance has improved significantly since the end of the war, shifting towards a closer balance between imports and exports, but it remains high with imports 36% higher than exports. In 2004, imports reached $2.0 billion and exports $1.47 billion. There is significant export growth, led by Mozal's aluminium exports, which greatly expanded the nation's trade volume, along with growth in traditional exports of cashews, shrimp, fish,

copra, sugar, cotton, tea, and citrus fruits. Mozambique is also becoming less dependent on imports of basic foods and also of light manufactured goods due to a steady increase in local production.

Despite the major progress that Mozambique has made to reduce poverty, it remains one of the poorest countries in the world, with a GNP per capita of $210 (in the mid-1980s it was just $120) and with over 70% of the population still living in rural areas. Endemic diseases such as malaria, tuberculosis and HIV/AIDS are constant threats to all. About 14% of the adult population is HIV positive, a number that is rising exponentially. Mozambique's Human Development Index of 0.379 for 2005 ranks it in the 168th position out of 177. A major barrier to socio-economic development is a high illiteracy rate of 54%, which reaches 69% among women.

Thus Mozambique's development trajectory is vulnerable. Continued economic growth, decline in the poverty level, and improvement in related socio-economic indicators cannot be assumed. It has been shown that at a prevalence rate of 15% for HIV, a 0.8% reduction in GDP growth per capita occurs. GDP growth from 1997 to 1999 averaged more than 10% per year, but it was cut drastically to 2.1% by the devastating floods of early 2000. Mozambique's progress in poverty reduction and economic development is therefore subject to substantial reversals.

Socio-economic progress faces several challenges and constraints within the public and private sectors. There is an increasing disparity between the booming mega-projects sector (Mozal aluminium smelter, the Sasol gas project, the Maputo Port, the Marromeu sugar project and the Beira Railway Project) and the SME sector that the business environment does not support adequately. Furthermore, there are inadequate policies and instruments for attracting investment in research and development (R&D) that would serve to strengthen the private sector. Continued rapid economic expansion hinges on the few major foreign investment projects, ongoing economic reform, a vigorous promotion of expansion in agriculture, the revival of the transportation and tourism sectors and a diversification of manufacturing.

Although Mozambique is a country rich in natural resources (coal, titanium, natural gas, hydroelectric power, tantalum, graphite), most of these are not yet exploited. Its

economy is heavily dependent on small-scale agriculture, which engages more than 75% of the population. Agricultural production suffers from inadequate infrastructure and the lack of commercial networks and investment. Remarkably, 88% of Mozambique's arable land is still uncultivated. Thus, focusing on economic growth in the agricultural sector is a key policy challenge.

Over 70% of the population lives in rural areas and a sizeable portion of these are vulnerable to floods and drought. Therefore, in the current circumstances, poverty and vulnerability are largely rural problems. However, a significant increase in migration to urban areas may be anticipated due to the country's continued economic development, fuelled significantly by the implementation over the next decade of resource-based development projects and the expansion of the services sector. Based on the experience of other developing countries, such an increase in the urban population is likely to give rise to new problems related to urban poverty, including cultural dislocation, the need for water, sanitation and waste management, an increase in unemployment, and the growth of the informal market sector.

1.2 The Status of Research

Foundational to the S&T system are the research functions that generate new knowledge through R&D, both to address problems in Mozambique that require unique solutions based on local research, and to acquire existing technologies and adapt them for local use. Generally, R&D is carried out in the context of universities (both public and private) and in research institutes (generally public). Very often the universities tend to conduct basic research while research institutes will focus their efforts on applied research that has potential benefits for one or more sectors.

The UEM contributed about half of the 240 research publications that were published during the period 1997 to 2003, followed by the National Institute of Health and hospitals who contributed about one fourth.

1.2.1 Research Institutes

Mozambique has sixteen Public Scientific and Technological Research Institutes (IPPCTs) with Research, Development, Engineering and Extension mandates, as shown in Appendix 2. The annual funding of these institutes amounts to $22.1 million, of which about $7.5 million

is provided from the State Treasury. Public expenditure on research and development amounts to about 0.2% of GDP, which is insufficient. The focus of the IPPCTs lies chiefly on applied research and extension. Some IPPCTs, in particular those involved in the exploitation of natural resources (forestry, fishery), engage in monitoring research.

Less than 30% of the institutes' full-time personnel who have higher-education qualifications (226 staff members) have a postgraduate degree, and of those only 27% have a doctorate degree. Over 60% of the doctorates are held by staff in the agricultural sciences institutes, with IIAM alone accounting for 50%. Of the master's degrees, 77% are also in the agricultural field. The fields with the lowest proportion of researchers with postgraduate degrees in relation to the total number of researchers are engineering and earth sciences (3 out of 12) and health sciences (12 out of 45). In addition, health sciences have the largest share of foreign researchers.

About 77% of all researchers are employed full time. Researchers who are employed part-time are particularly important in the Health Sciences area where they represent 142% of full-time researchers. There are also three times more part-time researchers with doctorates and five times more part-time researchers with master's degrees in this area. Almost 60% of full-time researchers are between 35 and 49 years of age and less than 35% are under 34 years of age. Women account for just 20% of the total number of researchers in the IPPCTs.

The overall number of full-time researchers per computer, and per computer with Internet access was 0.83 and 1.48, respectively. The number per computer was lowest in Fisheries (0.37) and highest in Social Sciences (1.90) and Agricultural Sciences (1.11). The number per computer with Internet access was lowest in Fisheries again and highest in Forestry.

1.2.2 Research at Universities

Almost all university research is carried out in the public universities, which employ over 60% of the lecturers with masters degrees and about 80% of those with doctorates.

The top three (and oldest) public universities – UEM, UP, and ISRI – have well-established research activities. UEM has more than 300 different research projects underway, and UP and ISRI have also been increasing their research efforts recently. Several public universities have sought to institutionalise on-campus research by introducing research-based

Licentiate thesis programmes and by establishing research funds for that purpose (such as UEM). The public universities focus primarily on applied research, followed by basic research and extension (services provision). Almost all of the research is funded by external foreign sources, which influence very significantly the type of research pursued. In recent years a few private universities (ISCTEM, ISUTC, ISPU, UCM, UDM) have also launched research efforts.

1.2.3 Dissemination of Scientific Knowledge

Dissemination of research, by both public universities and research institutes, occurs mainly through publication in internal journals or booklets, as there are few peer reviewed scientific journals in Mozambique. Recently, UEM Press began to publish books and other publications, contributing to the dissemination of some research results.

Statistics on research results is sparse. UEM has since the late 1990s been publishing a biannual report of its faculties' research results but the quality of the data remains uneven. Public research institutes have also been publishing annual reports, which provide some data, although the presentation format and coverage may vary from year to year.

1.2.4 Funding

While all salaries in public universities and research institutes are paid out of the government budget, most research funding comes from foreign sources. However, there is considerable variation in funding between research areas in the research institutes. In 2002 foreign funds accounted for over 80% of research funding in the Social Sciences and Humanities, 70% in the Health Sciences, 51% in the Engineering and Earth Sciences, 56% in the Agricultural Sciences and 100% in Forestry.

The Fund for Poverty Research (Fundo de Investigação sobre Pobreza - FIP), originally managed by the MESCT, and now at the MCT, is a competitive programme aimed at promoting research that contributes to knowledge improvement and an understanding of poverty in the country, as an input for an effective and efficient national strategy for poverty reduction. For the current bidding cycle the eligible areas are: (1) poverty in poor and marginalised groups in rural and urban zones and (2) impact studies, related to the PARPA II implementation, focused on testing alternatives to poverty-related problems.

1.3 The Higher Education System

Mozambique has experienced a rapid expansion of higher education in the past two decades. By 2003 the number of public Higher Education Institutions (HEIs) had increased from one to five, while five new private institutions were founded. Student enrolment mirrored these increases, rising some five fold to over 22 000 in 2004, with about two-thirds of the student population in public institutions. Nearly 80% of the student population is to be found in Maputo, followed by Nampula (11%) and Sofala (9%). However, growth rates in the provinces are greater than those in Maputo so this provincial imbalance is starting to be corrected.

There are currently just under 8 000 undergraduate students enrolled in the natural sciences and engineering, representing about 34% of total enrolment, and the rate of growth of this number exceeds the growth rate of the total student enrolment. Some 60% of these enrolments are in the southern provinces of Maputo, Gaza and Inhambane. Concerning graduate students, in 2003 there were only 63 students in the natural sciences and engineering, all based at UEM in Maputo.

The total number of teaching staff in the tertiary education system increased from about 1 500 in the year 2000 to about 3 700 in 2004. Of these, less than 25% are women. There were some 1 185 full-time staff in 2004 (32% of the total). Of these, about 20% had master's degrees and only 13% had PhDs.

1.4 Information and Communication Technologies

1.4.1 The Role of ICTs

Information and communication technologies (ICTs) are enabling and crosscutting tools, which provide solutions for all areas of development. ICTs will enable Mozambicans to access the benefits of worldwide knowledge resources, raise the efficacy and efficiency of State institutions and their value to the public through provision of services, improve quality of governance and public administration, and help raise Mozambique to the level of a valued and competitive partner in the Global Information Society.

ICTs are often perceived merely as tools, without recognising their transformative role, enabling change in the mindsets of both private and public institutions and the way organizations and individuals communicate, operate and exchange knowledge. ICT solutions

involve more than just technology. They need adaptation and contextualization, taking into account local cultures, languages and customs. Their role in development may be understood only by grasping how they have changed profoundly the way institutions, individuals and the global society operate. ICTs by nature:

- Remove the effect of physical distances, and enhance real-time exchange of knowledge;
- Promote networking of institutions, individuals and geographic regions;
- Promote collaboration and sharing of knowledge between stakeholders;
- Introduce new channels for service delivery;
- Promote economies of scale and replication of developed solutions;
- Promote transparency and openness;
- Promote open and multi-directional communication.

The role of ICTs in poverty alleviation is crucial through rapid adoption and dissemination of content, best practises and knowledge, through providing efficient communication networks for development practitioners and service providers, and through access to global and regional markets and online services.

1.4.2 National ICT Policy and Strategy Framework

The national ICT Policy, approved in 2000, defines broad objectives for harnessing ICTs as an engine for development. The policy also states that "Mozambique should become a producer, not a mere consumer, of Information and Communication Technologies", which indicates that the government is committed to supporting the establishment of a viable local ICT sector. The challenges and objectives identified in the policy were developed further in the ICT Policy Implementation Strategy, approved by the Council of Ministers in June 2002. This ICT strategy recognises three major challenges to achieve the rapid spread of the use of ICTs in Mozambique:

- Increase of the base of human resources with solid skills in ICTs and their availability throughout the country;
- Expansion and modernisation of the telecommunications infrastructure in the country;
- Acceleration of the process of defining the telecommunications policy and the reform of this sector so as to facilitate free competition and attract investment.

The ICT Policy Implementation Strategy has the following objectives:

- To raise people's awareness of ICTs and their potential for development;
- To combat absolute poverty and to raise living standards;
- To provide universal access to information so that citizens may improve their professional performance and gain benefits in areas such as education, science and technology, health and culture;
- To expand the use of ICTs in the national education system ;
- To encourage and support ICT training for managers, community leaders, women, youth and children;
- To improve the efficiency of the public and private sectors, and to promote investment in ICTs;
- To help reduce existing imbalances between regions, between urban and rural areas and between different societal segments, promoting equal access to development opportunities.

It also defines clear roles for the Government, the private sector, higher education and research institutes and civil society for implementing the wide range of initiatives identified in the strategy, under the coordination of the national ICT Policy Commission. Specific programmes to support these initiatives are either underway or must be developed, addressing the following priority issues:

- Education
- The Development of Human Resources
- Health
- Universal Access
- A National Support Infrastructure for ICTs
- Governance
- Agriculture and Natural Resources
- The Environment and Tourism
- Public Protection
- Electronic Commerce and the Protection of Business
- A National Network of Academic and Research Institutions
- Women and Youth
- Culture and Art
- Social Communication

1.5 Vision and Mission for Science and Technology

The purpose of the Mozambique Science, Technology and Innovation Strategy (MOSTIS) is to establish a set of priorities and a corresponding enabling framework in order to enhance the contribution of science, technology and innovation (STI) towards achieving the national imperatives of poverty reduction, economic growth and the social well being of all Mozambicans. It identifies a set of strategic objectives and related programmes to achieve the objectives. Mozambique's vision for STI is:

> *The ubiquitous and equitable availability and use of Science, Technology, Innovation and ICTs as a right of all Mozambicans, in order to accelerate poverty reduction, wealth creation and the improvement of their social wellbeing.*

The scarcity of resources demands that science and technology activities be directed to areas and sectors where the largest impact may be achieved, both direct and indirect, on poverty reduction, wealth creation and improvement of social well being. Therefore the Mission of MCT is:

> *To promote the supply of scientific and technological solutions to priority sectors defined in the Government's five year programme (2005-2009), PARPA, Agenda 2025, and other national development programmes, aiming at improvement in the quality of life of Mozambican society.*

MCT's approach may be summarised by a policy focus on the promotion of multidisciplinary, multi-stakeholder research targeted to problems affecting the most vulnerable social groups, private sector financial involvement and S&T cooperation and democratisation.

Following an analysis of the strengths and weaknesses of the Mozambican economy and society, and of Mozambican science and technology, the potential threats that must be faced along with the opportunities and challenges that exist, several strategic areas were identified to serve as the strategic focus of the MOSTIS, for the development of the country as a whole. In addition, in the context of a vision for sustained and harmonised development, strategic crosscutting issues were identified. These crosscutting issues have the potential to

impact, directly or indirectly, on the dynamics of the strategic areas, and by addressing them, progress in each strategic area may be boosted. The strategic areas include:

- Human Resource Development; Agriculture; Education; Health; Energy; Marine Sciences and Fishing; Construction; Water; and Mineral Resources,

The sustainable development of these strategic areas will only be achieved provided the following strategic crosscutting issues are addressed in parallel:

- Social and Human Sciences and Culture; Environmental sustainability; Ethno-botany; Gender equity; HIV/AIDS;

In addition, the approach of the strategy is to harness the potential of enabling and crosscutting technologies such as:

- ICTs and Biotechnology.

The mission and strategy will be undertaken through a set of research, innovation and technology transfer programmes for development that are agreed to by means of a consensual process amongst stakeholders. Strategic guidelines will ensure that the implementation of the programmes is aligned both with policy and with related initiatives undertaken by other stakeholders (such as other Ministries). Implementation will also be coordinated and managed to ensure that the objectives and their related milestones are met in a timely manner. The programmes will support the achievement of several strategic objectives that have been developed with a focus on the strategic areas mentioned above.

The implementation of this vision and mission will require instilling an entrepreneurial attitude in Mozambican society for dealing with both social and economic challenges. This will be achieved through a self-evolving and learning-driven system of institutions, policies and processes geared to the strategic objectives, which will form the basis for an integrated, transparent and well-governed national system of innovation made up institutions with defined and recognised roles, a high level of collaboration between the institutions, a range of funding mechanisms with appropriate measurement and incentive schemes, open policies, a free flow of information, and solid infrastructure. It will also be necessary to strengthen the institutional capacity of MCT for designing, financing and monitoring innovative and networked public-private partnerships, for continuous learning and for the diffusion of knowledge.

1.6 Development Challenges

Economic growth has faltered and has not been accompanied by sufficient diversification in economic activities and exports. There are many sectors with significant potential that is yet to be realised, and Mozambique remains heavily dependent on external assistance, which accounts for about 17% of GDP or almost $600 million a year. External aid finances over half of government spending and 75% of public investments. Linkages between institutions within growth sectors are absent or weak, and SME creation and expansion in emerging sectors is stunted by a lack of entrepreneurial incentives and business development services.

A major development challenge for Mozambique lies in the fact that it has a large and growing population. More importantly, it has a predominantly young population: 43% of the population of 19.1 million (2004) is less than 15 years of age, so the rate at which young people will enter the labour market over the next few years will increase dramatically.

The HIV/AIDS pandemic represents a particular development challenge. In addition to the human tragedy for those affected by the disease, it is changing the demographics of the country, and will continue to do so if action is not taken. This in turn impacts upon the productive capacity of the workforce. Attention should be paid not only to making information available to the public on ways to prevent becoming infected and infecting others, and on the support of dependants, but also to research into treatment strategies and into ways of mitigating the impact of the pandemic.

Mozambique has a severe lack of well-qualified researchers and technology professionals. Addressing this issue adequately requires a long-term (up to 30 years) commitment to the development of human capital, with particular focus on the sciences, engineering and ICTs. If such a commitment is not made now, then this inadequacy will continue to stunt the country's growth and potential. As Mozambique continues moving up the development curve, and engaging with the global economy on ever widening fronts, the nature of the challenges will change and the complexity of the problems will increase, requiring ever higher levels of scientific, technological and innovative capabilities and capacities. Furthermore, an educated and flexibly skilled workforce is a potent attraction to foreign investors. Increased scientific capacity contributes to improved technology for solving complex development problems and generating value-added products and services. STI competence building must therefore move to the top of the development agenda. In fact,

the very practice of STI competence building produces a set of institutions and incentive systems, organisational culture and personal habits that should facilitate the process of incorporating STI competencies throughout the social, economic and political structures of society.

At the same time, the short and medium term challenge to reduce poverty must be faced and addressed. STI must be used in creative ways to give those caught in poverty the means of conceptualising, designing and implementing solutions to improve their quality of life. The constraints imposed by limited resources demand that the potential for innovation in even the most isolated communities be tapped through the appropriate introduction of scientific and technological knowledge and approaches. The ways and means of giving effect to this must be informed by learning from the experience of other leaders in poverty reduction. It should be recognised that very often the new solutions that prove most effective will be designed by local talent, based on new research and development. It should also be recognised that any solutions must be fully adapted to local circumstances and make full use of indigenous knowledge systems. The rich cultural heritage within Mozambique should be both respected and promoted by STI interventions. Often, local skills can devise new solutions that can be further perfected through R&D.

1.7 Regional and international collaboration

Mozambique's strategy for STI is aligned with the approaches and initiatives of the African Union and NEPAD and with international bodies such as UNESCO. A desk on science and technology is being established by SADC, aimed at promoting cooperation within the region. The overriding goal is to use S&T to support the achievement of the Millennium Development Goals.

Mozambique will seek ways of promoting regional cooperation in the use of S&T for development, as many problems of development may best be solved with strong regional cooperation. Some issues have an inherent regional aspect, such as food security. Others can require resources that would exceed the capacity of a single developing country to supply, such as HIV/AIDS.

The attention of the international community is on the role of S&T in sustainable development and poverty reduction. As Mozambique succeeds in using S&T as a weapon in the fight against poverty there will be opportunities to extend these successes on a regional and continental basis. Mozambique should actively partner with its neighbours, regional and Africa-wide institutions, and with funding partners to capitalise on successes and extend learning, for mutual and equitable benefit. This would include establishing linkages between relevant institutions within the region and continent to best exploit scarce resources.

2 Science, Technology, Innovation and Knowledge

2.1 STI for Poverty Reduction and Economic Development

The challenge for science, technology and innovation in Mozambique is to make a significant contribution in the fight against poverty, as well as to enable and drive economic development. The challenge lies in identifying and implementing policies and interventions that are appropriate to the unique set of circumstances in any particular country so that the potential of STI can be realised.

While there is a growing consensus that STI has an important role to play in contributing to poverty reduction, the optimal ways of achieving this are still emerging. At the same time, Mozambique has extremely limited resources related to S&T expertise, infrastructure and finances, which places severe constraints on what is possible in the short term. In addition, there is a range of factors that can result in increased poverty, and can inhibit growth and development, if they are not addressed in some way (such as widespread disease and natural disasters). Furthermore, the causes of poverty are multifaceted and addressing any single factor is unlikely to result in poverty reduction. The dynamics that keep people in poverty form part of a large and complex system. To achieve a substantial reduction in poverty a systemic and holistic approach is necessary, with long-term commitment at the highest levels. S&T has an important, even essential, role to play, although S&T alone is insufficient.

By focusing on this particular strategic priority Mozambique aims to be amongst the leaders in the world in harnessing science, technology and innovation to address directly the needs of remote and impoverished communities. Therefore, innovation in the context of the MOSTIS refers both to the process by which new products and services enter the market,

including the creation of new businesses, and to innovation by poor and remote communities themselves, based on indigenous and other knowledge to improve their quality of life. (The latter is referred to as grass-roots innovation in this document.) Both types of innovation are key within the MOSTIS.

In linking STI to poverty reduction as the major goal of the MOSTIS, the approach is to promote, for example, the use of innovative information and communications technologies (ICTs), results from scientific R&D, and the adaptation of existing technologies, to improve the quality of implementation of initiatives by and for impoverished communities. This will be coupled to focusing on the priorities identified in PARPA II and will be done in partnership with line ministries, civil society and private sector stakeholders. The MOSTIS will enable the voices of the poorest sectors to be heard by society, and science and technology will be used to give them the means to gain the upper hand against poverty.

As the country succeeds in its battle against poverty and incorporates ever larger segments of the population into the market economy, a new set of basic problems, related to matters such as health, sanitation and education, may emerge in the urban areas. In order to continue enabling an increasing number of citizens to improve their quality of life, and for the country to continue on its economic growth trajectory, new scientific research, technological developments and innovative products and services will be necessary so that more people can be absorbed into the urban areas. At the same time, efforts should be made to encourage development in rural areas so that migration to urban areas is not perceived as the only answer to poverty. The MOSTIS will therefore address the need to build the fundamental capabilities and capacities that are needed to deal with these emerging challenges amongst the rural, and also the urban, poor.

The crosscutting nature of STI must be recognised, and therefore the need to work in inter-disciplinary ways across and with multiple ministries. The MOSTIS will promote cooperation amongst agencies within the public sector, and with institutions in the private sector, and with Non-governmental Organisations (NGOs) and Community-based Organisations (CBOs). Such cooperation should be directed, in particular, towards concrete programmes of action that serve to support the achievement of the strategic objectives of the MOSTIS.

2.2 Knowledge as a Resource for Production

In recent years the advantages of a country being endowed with natural resources as a foundation for economic development, and of having labour costs that are highly competitive for industrial manufacturing, are increasingly being superseded by dynamic competitive advantages based on the harnessing of scientific research and technological advancement, the mobilisation of technically-trained human resources and the spread of an entrepreneurial culture. The rapid creation and diffusion of knowledge based on scientific research, technological progress and societal experience has resulted in knowledge becoming the major driver of social and economic transformation in developed and developing nations. ICTs are primarily responsible for this change and they also lie behind the quickening pace of communication between countries and continents.

In the emerging knowledge economy, with ICTs being key components for knowledge-led development, particularly in the growing services industries, and in expanding global markets with complex, technology-driven manufacturing systems and open, multi-stakeholder innovation chains, the ability to generate new knowledge, not least through education and skills renewal, and the ability to deploy knowledge through innovation, is crucial for sustained economic performance and the improvement of the quality of life in Mozambique.

In short, knowledge is the primary resource for production for Mozambique. The links between science, technology and innovation in the generation and application of such knowledge are multifaceted and interactive, requiring continued support and the right incentives to promote continued renewal through new research problems, new technological frontiers and new innovation paradigms.

2.3 Knowledge-led Development

Knowledge can be obtained from different sources. One such source is the experience accumulated over generations, residing in indigenous knowledge systems. For example, knowledge about medicinal plants has been an important, and at times the only, means of treatment in various isolated communities. While such knowledge has often enabled societies to survive, it can prove to be inadequate as an engine of development and as the only basis for responding to problems faced by modern society. It should be supplemented with knowledge derived from applicable science and technology.

The key to poverty reduction is the application of knowledge, not only by those with resources and influence, but by those who are themselves caught in a spiral of poverty. The understanding and use of basic scientific approaches, and the replication of proven and working solutions, can dramatically improve problem solving and decision-making, even in the poorest and most remote communities. The challenge for the Mozambican government is to find ways of enabling those caught in poverty to acquire and use knowledge to address their problems.

A key lesson extracted from assessments of well-functioning knowledge economies point to the critical role of effective learning systems. The building of a learning infrastructure for Mozambique's knowledge economy includes investing in a wide range of new, more effective and demand-driven learning environments. A skilled and educated workforce can identify problems and use its knowledge effectively to solve them. Second, an appropriate economic and institutional regime is required to provide the right system of incentives for the creation, adaptation, dissemination and deployment of new and existing knowledge. Third, a solid base of R&D activities is needed in Mozambique to generate new and relevant knowledge, and fourth, all must be supported by an effective information infrastructure. A suitable information infrastructure enables and enhances the collection of data, its transformation into information, and its subsequent communication, diffusion, processing and use. Moreover, it facilitates the formation of social and organisational networks, which form the basis of well-functioning knowledge communities. Finally, Mozambican society must be informed continuously by a shared vision that is the result of, and is sustained by, strong consensus-building processes. These considerations all support the need for a clear policy and strategy for Mozambique to follow as it builds a knowledge economy.

Given the broad impact of the knowledge economy it becomes an imperative for Mozambique to design development-centred strategies for building a knowledge economy. The education of Mozambique's citizens, particularly in S&T, must be aimed at enabling them to participate in the knowledge economy. Historically, women have been disadvantaged in accessing S&T educational resources, inadequate as they were. Therefore policies and strategies are needed to promote gender equality within S&T, in particular to encourage and enable more women to gain learning and expertise in S&T. It is essential that effective

policies and strategies are pursued to enable rural communities in particular to become more integrated in the knowledge economy. Furthermore, all Mozambicans should be made aware of what is at stake.

The accelerating and widening scope of technological progress based on scientific research creates the framework for a knowledge society. Closely associated is the explosion in capability and efficiency of ICTs which enable and drive economic growth and linkages to international markets. In this context, Mozambique should choose to make selective use of available knowledge, and related tools and technologies, to avoid or minimise lengthy stages of development (where this is possible and desirable) to quickly integrate into the global economy in targeted areas.

Therefore, integral to the MOSTIS is the establishment of a viable and effective knowledge sharing culture, with associated systems, to assist ministries and government agencies in identifying, conceptualising, designing, planning and implementing knowledge-based solutions for the reduction of poverty and for economic development.

3 Strategic Framework and Strategic Areas

3.1 Strategic Action Fronts

The MOSTIS is guided by a model concerning the relationship between science, technology and society, and involving three strategic action fronts, as shown in Figure 3.1.

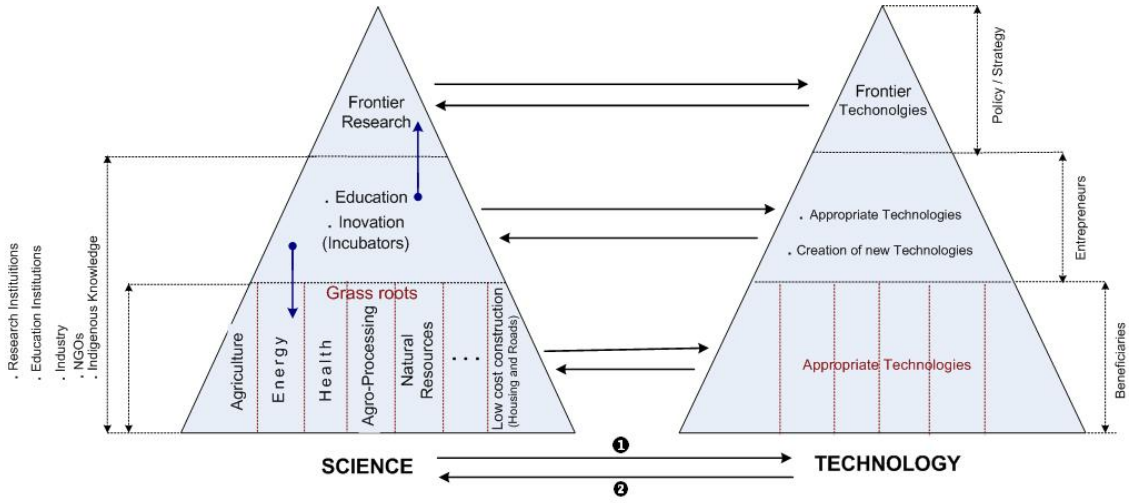


Figure 3-1: The Relationship between Science and Technology

In the first place the model depicts the two-way relationship between science and technology. Central to science is research, and the aim of any research undertaking is to generate new knowledge. The quest for this new knowledge may be driven by some practical problem directly related to human need, or the primary driver may simply be the desire to advance human knowledge. In either case, the knowledge thus generated may be applied to solve a practical problem related to, for example, society, the economy, or a community, through the development of appropriate technology. This process of moving from science to technology directed at solving a real-world problem is depicted by the arrow marked ❶.

There is, in addition, a complementary movement from technology to science. Any technology used in a given solution will become obsolete over time. Furthermore, the characteristics of the problem being solved may change. In either case there may be a need to renew the technology through research efforts directed by the requirements defined by the new form of the problem, or advances in technology. This complementary movement from technology to science is depicted by the arrow marked ❷. In general there will be a continuous cycle involving the renewal of technology-based interventions through the production of new knowledge through research.

The model also includes the concept of three strategic action fronts as depicted by the three sections of each triangle, as follows:

- The base of the triangle represents applied and adaptive research and technology generation, which leads to improvement of production and the social well being of the population. Using the base to represent this front indicates that a large proportion of the resources and technological solutions of government and its partners will target the poor and most vulnerable groups such as subsistence farmers, women, the old and youth, who make up the majority of the population. The agencies at this level include the research institutions, higher education institutions, and other agents involved in development activities. Research at this front is expected to be mainly of a multidisciplinary nature and will make maximum use of off-the-shelf knowledge and technologies, which will be adapted to local conditions. Most of the strategic areas are to be found in this part of the triangle.

- The middle section of the triangle represents research that is relevant to, and improves the quality of, education, as well as for the development of innovation capacity through, for example, creating linkages between academic research staff and industry, and technology business incubators. The aim is to build the national wealth creation capacity through the creation of appropriate and new technologies by entrepreneurs, and through encouraging technology transfer. Institutions of higher learning will play a key role in this front, as will institutions focused on innovation and the creation of commercially viable small, medium and micro enterprises. The strategic crosscutting areas are to be found in this part of the triangle.

  There are two vertical arrows, one pointing up from the middle section into the top section, and the other pointing down from the middle section to the bottom section. These two arrows indicate that research and education that are depicted by the middle section are essential both for the top section (Frontier research) and for the bottom section (grass roots).

- The top of the triangle represents frontier research. By being active in this area Mozambique will establish a place for itself within the global science and technology arena. This front will therefore foster national interests, which include an enhanced national competitive edge, national sovereignty and national security.

The success of the first two action fronts (base and middle) will require that the institutional capacity of MCT be strengthened at the different levels of management and administration of science and technology to ensure the sustainability of the processes in terms of planning, implementation, monitoring and evaluation. In addition, MCT will promote the establishment of science and technology centres of excellence throughout the country, in partnership with the relevant line ministries. These will serve to identify development problems, and will disseminate relevant research results and implement appropriate technology-based solutions for the benefit of the end users.

The third action front relates to the promotion of frontier research. In general the financial return from this type of research may not be visible in the short term, so evaluation of such research should be based on a long-term perspective. Frontier research in most cases requires a large investment when compared to applied research directed to solving the immediate problems of the majority of the population. MCT is aware of this and will

promote this activity only when it is possible. However, it is important to evaluate options in this area from a strategic perspective, informed by:

- Mozambique's vision regarding its position in science and technology in the region and in the world;
- Mozambique's capacity to invest in human resource development in highly specialised areas, other than those that are strategic for development.

3.2 Strategic Factors

Mozambique's striking progress in poverty reduction and economic development, as described above (section 1.1), is largely due to the positive evolution of policies and a focus on institutional development. First, economic policies and institutions have been enhanced in their functional scope and in their capacity for governance. Second, accountability procedures and mechanisms have been put in place. Third, coordination between institutions has been improved, and fourth, access to basic services is being improved, independent of geographic location. These enhancements to policy and to institutional capacity and effectiveness serve the overarching goal of having both the state and society at large engaged effectively in the fight against poverty, along with supporting other important goals concerning economic development, peace and empowerment.

In light of the fundamentally transforming role of S&T, its pervasive and crosscutting nature, the size and spatial distribution of Mozambique's mostly rural population, and the extent and diversity of the activities necessary to effectively accomplish the poverty reduction goals of PARPA II, an MCT-led STI strategy should be pursued within the framework of the following strategic factors:

- Facilitation
- Articulation
- Management
- Funding
- Learning to learn

These factors should be supported by an approach that includes paying attention to:

- Legislation and regulations
- Coordination across all sectors

- Showing by doing

First, the MOSTIS ought to *facilitate* the transfer of technology. This involves assisting other agencies in the system to identify their S&T needs, to provide mechanisms for the creation of capacity to absorb S&T, to screen and assess existing technologies and diffusion mechanisms, to adapt and refine them to local user conditions and cost-effective implementation, to deploy them in a timely and efficient manner, and to evaluate their experiences and so learn from them. In many cases the facilitation of technology transfer will have to address the financial constraints of those involved through, for example, the establishment of special lines of credit.

Second, the MOSTIS ought to entice various agencies to perceive the need for S&T, and so to *articulate* the importance of S&T for their visions and for the processes leading to the efficient fulfilment of their mission and objectives.

Third, the MOSTIS ought to *manage* (a) the aggregation and coordination of S&T users and beneficiaries' needs, interests and expectations, and (b) the process of policy-making among stakeholders with contrasting missions, capabilities and competencies.

Fourth, the MOSTIS will need to pursue its strategic objectives through funding. Funding serves as a powerful incentive as it entices diverse stakeholders to cooperate in the context of converging interests, with a shared vision and toward common goals. It also allows for flexible research priority targeting and effective results-based policy monitoring.

Fifth, the MOSTIS ought to promote learning to learn at all levels and across all areas. Learning to learn may be characterised as follows:

- It includes monitoring and evaluating the impacts and implications of the learning, and questioning the assumptions upon which the current learning topic is based, irrespective of how entrenched the assumptions are;
- It identifies what works well, and extracts the principles that lie behind the successes;
- By understanding the principles that underlie examples of successful initiatives, it makes appropriate adaptations and undertakes wide-scale replication of such initiatives;
- It needs to be practiced at individual, group, organisational and societal levels;
- It is based on an awareness of systems and systemic relationships and interactions;

- It is primarily qualitative, rather than quantitative;
- Of late, complexity and chaos theories offer further opportunities to understand the processes of learning to learn.

It is essential that agencies and stakeholders are encouraged and assisted to practice learning to learn for the success of the implementation of the MOSTIS.

3.3 The Strategic Areas and Strategic Crosscutting Areas

In the context of pressing national priorities and limited resources, and in order to break out of a spiral of dependence, it is important that Mozambique should focus investments in STI within strategic areas. Following an analysis of the strengths and weaknesses of the Mozambican economy and society and of Mozambican science and technology, the potential threats that must be faced, along with the opportunities and challenges that exist for developing the potential of the country and its people, several *strategic areas* have been identified, along with several *strategic crosscutting areas*. The thrusts of the MOSTIS towards poverty reduction, and also towards the economic development of the country, will focus primarily on these areas.

The strategic areas include:

- Human Resource Development
- Education
- Agriculture
- Health
- Energy
- Marine sciences and fishing
- Construction
- Water
- Mineral resources

The strategic crosscutting areas include:

- Social and Human Sciences and Culture
- Gender Equity
- Ethno-botany
- HIV/AIDS

- Environmental sustainability

The enabling and crosscutting technologies that act as catalysts of development in the strategic areas are:

- ICT
- Biotechnology

Strategic concerns and priorities for each of these areas are discussed in the following sections.

4 Strategic Areas

The strategic issues and research lines that are listed below for each strategic area have been identified through a process of interaction with representatives of each particular area. New research opportunities will have to be formulated by each area as part of an annual research plan that will be submitted to MCT for harmonisation with other areas through a National S&T Coordination meeting involving all stakeholders. Example programmes for addressing strategic issues, and research lines where relevant, are identified for the strategic areas in Appendices 3 to 9.

4.1 Human Resource Development

This strategic area is concerned with the development of human resources for the S&T system, in particular by the higher education institutions, and through lifelong learning.

4.1.1 Higher Education in the Sciences

The success of any strategy to use science and technology to achieve national priorities is crucially dependant on the training and retention of a critical mass of scientists and engineers. Although there has been rapid growth in student numbers in past years, both overall and within the science and engineering disciplines, for a population the size of Mozambique's the total student enrolment in higher education should be close to 70 000, rather than the current 17 000. This gap in itself presents a major challenge to the tertiary education system. Furthermore, the proportion of students enrolled in science or engineering should be increased. Enrolment in the natural sciences and engineering should be in the region of 50 000, in comparison with the current level of 8 000.

In addition to these quantitative deficiencies, the quality of the education is also at issue. Measures are needed to improve the quality of education in the science and

engineering disciplines, and in particular to increase the relevance of more specialised courses to the challenges in Mozambique that are amenable to S&T-based solutions. So for example, mechanisms should be established to enable and encourage the exposure of teaching and research staff in the HEIs to the industrial environment, to strengthen the practical grounding of what is taught and thereby achieve a better balance between the practical and the theoretical for their students.

University students are drawn towards the social sciences and humanities in preference to engineering and the natural sciences in part because of the poor quality of science education in the primary and secondary schools, but also because of the lack of demand for engineers and scientific personnel. Therefore a strategy to increase the numbers of science and engineering students should find the correct balance between supply and demand. Scholarship programmes will be needed to address the shortage of S&T graduates. Such programmes can be targeted at increasing the number of S&T graduates, with particular emphasis on female graduates. Scholarship programmes specifically for advanced degrees should also be established. Apart from undergraduate and graduate scholarship programmes, research-oriented, postdoctoral and sabbatical scholarship programmes should be established to encourage collaboration between Mozambican researchers and their regional and international colleagues, allowing access to the latest cutting-edge research and the stimulation of innovation within Mozambique.

There is currently a lack of graduate degree programmes, especially in the sciences, although new programmes are beginning to be established. The strengthening of these programmes, both existing and new, can have a positive effect on the retention of skilled personnel and on the growth of research activities at a university level in the medium and long term. The creation of further graduate degree programmes should be stimulated, but in the context of scarce resources, a focussed approach should be followed that targets national development priorities and avoids fragmentation and research efforts that attempt to operate with too few researchers.

Education should not be seen merely as a once-off activity that occurs at the start of a person’s career. Typically, after a newly-hired employee with an S&T education has worked for a period, they will require some further training that will make them more valuable to

their employer in terms of their outputs. After such training there may be some form of recognition by the employer of their additional value to the company or institution. The cycle may then repeat several times over the years. Thus the need should be recognised for education and training throughout a person's career, and there should be suitable educational and training mechanisms in S&T that will fulfil these needs.

The HEIs have been tasked to increase their number of graduates in S&T, and to expand their research activities in S&T. However, they are insufficiently resourced to optimally carry out these undertakings. MCT must therefore assist in mobilising resources to, for example, upgrade and expand infrastructure, including science laboratories, and to fund research activities. MCT should also provide direction concerning research activities to ensure that such activities are aligned with national priorities.

4.1.2 Retention of Highly-skilled Staff

The retention of university teaching and research staff can be difficult due to attractive compensation packages outside the education sector. Management and administrative positions are often more lucrative than research posts, which acts as an incentive for many to leave active research. To address this issue, careers in education and research may be made more attractive through long-term programmes of collaboration with international universities and research institutions that offer opportunities for advanced study and research. This should include sabbatical programmes that encourage leading international researchers to spend their sabbaticals in Mozambican research institutions, thus allowing high-quality interaction between local researchers and their international colleagues.

The creation of centres of excellence would also aid in attracting the best research staff and graduate students, and would contribute to developing human resources in S&T. Such centres of excellence should be focused on science and technology and lines of research that are relevant for promoting national development priorities. They should be established to facilitate cooperative research programmes and projects, in collaboration with other institutions, and allow for the sharing of research equipment, tools and facilities. Protocols should be established to enable the efficient and effective sharing of resources such as laboratories. Furthermore, there should be mechanisms that allow researchers from other

institutions to be allocated to research programmes and projects, in this way promoting the mobility of research staff.

4.1.3 Plan for Human Resource Development for STI

A strategic plan has been approved by the Council of Ministers (29 March 2006) for the development of human resources for STI, to address the severe need for additional properly-trained researchers. In 2002 there were some 470 researchers in the research institutions (excluding HEIs), which is woefully inadequate when compared to the levels in countries that are showing significant progress in S&T. Taking sub-Saharan Africa as a baseline, in which there are a little more than 200 researchers per million inhabitants, there would need to currently be more than 4000 researchers in Mozambique.

The plan calls for a stepped approach to meeting its full target of 6595 researchers by 2025, as follows:

Year	Number of researchers	Proportion of 2025 total
2010	660	10%
2015	2638	40%
2020	5276	80%
2025	6595	100%

It is intended that the researchers be trained in the following areas:

- Natural sciences (15%);
- Engineering and technology (20%);
- Medical sciences (20%);
- Agronomical sciences (20%);
- Social sciences (12.5%);
- Humanities (12.5%).

The plan will be achieved through four programmes for graduate and post-graduate training both inside and outside Mozambique. Provision is also made for support that includes infrastructure, teaching staff, research publications, a research fund and scholarships.

4.2 Education

This strategic area has to do with education in the school system (primary, secondary and intermediate) and the need to develop human resources with S&T skills in the long term.

The foundation of any strategy to increase the number of S&T graduates is the basic science and ICT education that is provided by the primary, secondary and intermediate education system. The basic sciences include mathematics, physics, chemistry and biology. In this area dramatic improvements are needed to prepare high-school students for pursuing science or engineering studies at a tertiary level.

Science laboratories are ill-equipped to prepare high-school students for pursuing science or engineering at a tertiary level. Access to computers and the Internet is inadequate. There are insufficient science and mathematics teachers, and many of the current teachers are not properly qualified. Furthermore, children both in primary and secondary school have insufficient exposure to science and technology in a form that will attract them to consider careers in science and technology when they are older.

Initiatives should therefore be undertaken to improve the laboratory infrastructure in schools, both for science and for ICT, across all of the provinces. When curricula are revised, attention should be paid especially to the S&T-related curricula. Programmes should be introduced to increase the numbers of teachers in the basic sciences, and to improve their qualifications. Furthermore, there should be programmes to popularise science amongst youth at an early age, thus creating an awareness and excitement concerning science and technology, and to enable and encourage students with talent in the sciences to further their education.

4.3 Agriculture

4.3.1 Introduction

Agriculture contributes about 26% to Mozambique's GDP and underlies the survival of 75% of its population. The agricultural sector has attained a relatively rapid growth rate, averaging

6.8% between 1996 and 2004. This rate, however, was less than the GDP growth rate of about 8.7% for the same period, mainly due to agriculture's vulnerability to natural disasters such as droughts and floods. The management of Mozambique's natural resources, which form the basis for agricultural development, must therefore be considered a national priority, supported by appropriate research efforts.

Mozambique has about 36 million hectares of arable land, with 3.3 million hectares being irrigable, and about 9 million hectares in the form of national parks and reservations. There are about 19 million hectares of forests, mainly in the northern and central regions of the country, about 12 million hectares of which have the potential for commercial exploitation.

The agriculture sector can be divided into two main segments:

- *Small-holder subsistence farming* which is responsible for about 94% of Mozambique's total agricultural production.
- *Commercial farms, which* are mostly owned by businesses, but with a small component of family ownership, and are responsible for the remaining 6% of agricultural production. This segment has demonstrated remarkable dynamism in recent years, with an average growth of 47.9% in the period 2001 to 2003. The primary focus is on cultivating and processing crops such as tobacco, cotton and sugar for the export market. During 2002 to 2004 agricultural exports increased by about 42% to $266 million (although non-agricultural exports increased by about 98% during the same period, to $1 235 million).

Although it represents only 6% of the agricultural sector, cattle breeding plays a key role in the provision of draught animals for agricultural use, and of fertilizer, as well as providing an important source of protein.

Despite its rich natural resources and enormous potential, Mozambique is a net importer of agricultural products. Total agricultural imports for 2003 were about $225 million, with wheat, rice and maize accounting for just over half of the imports. There is therefore a need for a strategy to increase agricultural production and diversification through improved yields and productivity, more effective agro-processing, access to more appropriate technologies, and improved land use.

4.3.2 Strategic Agricultural Issues

The agriculture strategy is founded on the promotion of research interventions leading to a more active and participative role of farmers in production to meet basic needs, to create self-sufficiency and well-being and ultimately for creating individual wealth as well as improving the country's wealth, on the basis of sustainable use and management of agricultural and natural resources. Agricultural research should prioritise applied research for the short term and medium term, based on the study of systems of production and socio-economic studies. It should emphasise participative and multi-disciplinary research, recognising agro-ecological differences, the importance of the regional advantages, the impact of value addition to agricultural products, and the opportunities presented by favourable environments for innovation and technological change, with the objective in particular to develop the family-oriented small-scale segment.

An immediate objective is to institute mechanisms for local prioritisation and responsibility so that the research agenda is more representative and is adapted to the main opportunities and limitations related to regional socio-economic development issues. In this context, three main pillars have been identified: industrial farming, small-holder farming, and agro-ecological sustainability.

Industrial Farming

There is a need to investigate and identify those areas in Mozambique whose specific attributes, such as soil types, could lead to sustainable industrial farming techniques, particularly in light of the large areas of the country that remain uncultivated. Strategic initiatives are needed involving the development of agro-industries aimed at raising household incomes of poor rural families. For example, there is scope to use STI to support agro-processing and the exploitation of hides, milk, meat, eggs and citrus products, as well as to improve technologies for use with draught animals. STI can help stimulate an effective agricultural export sector by:

- reducing the prevalence and impact of agricultural disease and infections;
- stimulating the production of agriculture surpluses for export; and
- producing statistics and analyses concerning relevant international markets.

Small-holder Farming

The predominance of the family-oriented small-scale farming segment justifies major STI interventions by the government. Because of its dominant size, a 1% improvement in production in this segment would equate to a 6% improvement in the business-owned commercial farming segment. The immediate goals of poverty eradication will be addressed with interventions aiming at ensuring basic production for subsistence needs, while at the same time considering means and technologies to improve production in order to go beyond subsistence to wealth creation.

One of the dilemmas of the role of agriculture in development is that while small-holder farming *alone* can rarely provide a reliable route out of poverty, nevertheless, widespread small-holder farming is necessary to address many aspects of that poverty (particularly food security) on a sustainable basis – i.e. it is an essential subcomponent of poverty eradication. Just as it is certain that small-holder farming will continue for the foreseeable future, it is equally certain that via STI, significant improvements can be made to the efficiency, productivity, marketability and environmental sustainability of many of the small-holder practices currently employed in Mozambique.

Agro-ecological Sustainability

Research programmes and projects focussing on Mozambique's agro-ecological potential need to be set up. Incentives should encourage researchers to carry out quality agricultural research aimed at development goals, sensitive to issues of environmental sustainability and the conservation of natural resources. Capacity building and training should produce enough researchers to provide Mozambique with technological independence, as well as fostering local, national and global networking. Local plants that may be used for pharmaceutical purposes should be catalogued. In addition, laboratory and testing capability and infrastructure should be established to meet international food safety requirements, so as to support food exports.

Research Infrastructure and Processes

Mechanisms are needed to guarantee strategic participation of stakeholders, including: the establishment of a Council for Agricultural Research supported by consultation forums (partners) at local and national levels; national and regional agricultural research meetings, as well as specific theme meetings. National policies are needed which:

- emphasise that there need be no conflict between agricultural modernization, small-holder farming, and agro-industrialization,
- encourage international investment in Mozambican agricultural research,
- make careers in agricultural research attractive, and
- stimulate public-private-partnerships in agricultural research (such as incubators, improved seed production).

The regional agricultural research centres need to be strengthened and developed, and focused on the different agro-ecological zones. Mechanisms should be established for technology dissemination and transfer, and for the evaluation of disseminated socio-economic technologies. Research should also focus on the production of livestock and crops that result in higher revenues.

Mozambique's farming sector (including farming communities, policy analysts and decision makers) needs to better understand the potential and benefits of STI and research, particularly as they relate to poverty reduction. This knowledge can come from formal training, or be easily accessed via a wide variety of informal sources, mechanisms and media (especially using ICTs), but must be culturally and linguistically sensitive. In addition, communication mechanisms and institutional collaboration between the different research stakeholders in the research and development system should be strengthened, such as between agricultural extension institutions, farmers, agro-industries and merchants.

4.3.3 Agricultural Research Lines

Stakeholders from the agricultural sector have identified the following areas of focus for relevant S&T research:

- Inventory, sustainable use, management and preservation of agricultural and natural resources (crops, livestock, soil, water, forestry, ethno-botanical resources);
- Data collation and sharing systems for natural resources and biodiversity;

- Characterisation of production systems and their potential impact on agro-ecological and socio-economic issues;
- Inventory and preservation of genetic material of local and adapted resources;
- Post-harvest preservation and processing technologies, including the link to the agro-industry;
- Application of enabling technologies such as biotechnology and breeding for the improvement of production and productivity of local resources (plants, animals, forestry) and exotic species;
- Development and adaptation of irrigation technologies for different production systems (small-holder and agro-industrial farming);
- Food quality control and safety;
- Control of diseases, vectors of diseases and pests of plants and animals, as well as zoonotic diseases;
- Ethno-botanical studies, to harness the potential of different plant species and promote their use in health and nutrition;
- Domestication and management of wildlife in captivity;
- Technology transfer in various fields of agriculture.

4.4 Health

4.4.1 Introduction

Poor health has a negative impact on the quality of life of Mozambican individuals, communities and society as a whole, as well as draining the economy due to reduced productivity, and the multiple costs related to all aspects of health-care. Perhaps less obvious, but particularly damaging to Mozambique in the longer term, are the many effects of poor health on education. Not only does poor health increase absenteeism of teachers and learners within the education system, but also a sick teacher is usually a poor teacher, and unhealthy learners (no matter how good the teacher) learn little, and often diminish the learning of those around them.

Effective health care is much more than the prevention and treatment of diseases and trauma. Often neglected, but of similar importance is the positive impact in Mozambique of good health. People seen to be “brimming with health” are usually happy, productive

individuals who often have an inspirational effect on those around them. At the individual level, good health has both physical and mental components, and can be stimulated by good nutrition, physical exercise, a mentally challenging environment (both in and out of work), a balanced life style, and a positive psyche.

4.4.2 Strategic Health Issues

In order to better coordinate health research in Mozambique and align it with national priorities, an advisory council on health research should be established that will advise the government on scientific health issues. To deal with ethical and related issues, a regulatory institution in the area of health research needs to be created. The existing National Institute for Health needs to be strengthened and reformed so that it may more effectively fulfil its mission to perform scientific research on health. Mechanisms and processes are needed to promote scientific research in health in the public sector, the private sector, and amongst NGOs. While significant progress has been made in health research, the diffusion of the resulting S&T can be improved; steps should be taken to strengthen diffusion channels. Finally, processes are required to allow for formal affiliation with the INS by health researchers who are employed by other public health institutions, thereby enabling them to be involved with INS research projects, and to receive the appropriate credit for their research.

4.4.3 Health Research Lines

Stakeholders from the health sector have identified the following areas of focus for relevant S&T research:

- Research leading to the enhancement of health policies and the health system;
- Diseases, and determinants of diseases, that have the largest impact on the health of the Mozambican population, such as HIV/AIDS, TB, malaria, intestinal parasites and other endemic diseases;
- Nutrition-related health issues, such as ways to improve nutrition, the health impact of poor nutrition; nutrient balance; alternative nutrients;
- Indigenous Knowledge Systems directed towards traditional medicine, including validation and dissemination of information concerning indigenous plants for medicinal and nutritional purposes.

4.5 Energy

4.5.1 Introduction

Reliable energy sources are fundamental to the aspirations for a good quality of life of all the people of Mozambique, as well as being essential for any sustainable economic development, including the emergence and growth of entrepreneurial ventures.

Over 70% of Mozambicans live in rural areas and depend on traditional fuels (especially wood), using inefficient and environmentally unsustainable technologies to try to satisfy their basic needs of nutrition, warmth and light. Efficient and effective energy systems are primary drivers of quality of life as well as sustainable economic activity and growth.

4.5.2 Strategic Energy Issues

Mozambique needs to aim at steadily improved access to modern energy, and to promote economic activities by increasing the availability of energy through the planned development of efficient and reliable energy supply systems. As traditional fuels will continue to be used for many years to come as a main energy source for a significant part of the Mozambican population, it is imperative to focus efforts towards the promotion of efficient use of traditional energy sources by means of STI. In parallel, new and renewable energy sources should be developed, particularly based on wind, solar, hydro, biogas and other sources. As this involves the use of systems for which components are not manufactured locally, incentive mechanisms such as subsidies and fiscal incentives should be considered.

4.5.3 Energy Research Lines

Stakeholders from the energy sector have identified the following areas of focus for relevant S&T research:

- The means of energy production, including bio-fuels, biomass gasification, biogas production, the production of briquettes, pellets and charcoal, and alternative energy sources, such as wind, photovoltaic and hydro, among others;
- The means of efficient use of energy, related to water decontamination, lighting, domestic and industrial ovens, and food preservation;

- Policies and programmes in the area of energy, including pricing, subsidies and fiscal incentives, as well as regulation on the efficiency of the technologies adopted in the production system.

4.6 Marine Sciences and Fishing

4.6.1 Introduction

Mozambique has a land surface of approximately 800 000 km^2 and a coastline of about 2 780 km in length. Its territorial waters cover an area of more than 100 000 km^2, and the inland waters an area of 20 000 km^2. There are numerous threats to the sustainable development of marine resources, such as pollution, imbalanced coastal development and over-exploitation of the ecosystems and resources. Therefore there is a need for management practices grounded on scientific principles, and of viable technologies for a sustainable use of the sea and the coast, to ensure the preservation of resources for today, and for future generations.

The most important marine resources include shallow water shrimp, deep sea prawns, lobsters, crab (both from deep water and mangrove), fish, sea weed, octopus and squids, among others. Fresh water resources are essentially fish. Approximately 32 800 ha of land are available for marine aquaculture, and there is potential for small-scale aquaculture in fresh water. Fishing is practised at the industrial, semi-industrial and small-scale level.

The livelihoods of large segments of impoverished coastal populations, and a growing share of exports, depend on fishing resources. Pristine coastal environments are also becoming a focal point of attraction for investment in tourism. Therefore, the comprehensive and systematic application of STI to Mozambique's coastal and inland fishing environments is likely to produce widespread benefits both for quality of life and for economic development.

4.6.2 Strategic Issues for Marine Sciences and Fishing

In the policy approved by the Government for the fishing sector, the goal for both capture and aquaculture is the increase of production for export and for supply of the local market, along with the improvement of the livelihood of fishermen, particularly in rural communities. This aims at sustainable development of the economy and of the communities involved in this activity.

As means to achieve this goal, research in fishing should focus on:

- Currently exploited resources of economic importance or that are relevant to the subsistence of concerned communities;
- Under-exploited resources of potential economic or nutritional significance;
- Improved knowledge of species with the potential for adaptation to aquaculture, as well as improved aquaculture techniques;

In parallel, marine sciences should perform comprehensive studies on marine and coastal ecosystems, characterise the main resources and promote their sustainable use, along with improving the techniques for environmental impact assessment.

The need has been identified to strengthen the capacity and capabilities of current Mozambican research institutions (including the introduction of world class expertise and equipment, as well as adequate numbers of researchers) by creating a national centre of excellence to stimulate and coordinate a wide range of research activities related to the Mozambican fishing sector. These institutions should follow an integrated approach to research, involving also higher education institutions. Such a task requires a coordinating and harmonising entity such as a Scientific Council for marine sciences and fishing.

4.6.3 Marine Sciences and Fishing Research Lines

Stakeholders from the marine sciences and fishing sector have identified the following areas of focus for S&T research relevant to that sector:

- Evaluation of the fishing resources and fishing management measures (differentiating between small-scale, semi-industrial and industrial fishing);
- Research on marine and aquatic environment (oceanography, limnology), and its relation to fishing resources;
- Research and selection of species with better genetic potential for improved quality of germlines;
- Research to address the issue of shrinking populations of species being fished;
- Research on fishing technologies that ensure sustainability of the fishing resources;
- Research on adequate fishing technologies to improve handling, processing and preservation, leading to added value of fishing products;

- Microbiological fishing research (main factors of contamination, and measures to conserve fish);
- Maintenance of good health and productivity of the marine and coastal ecosystems;
- Sustainable management of marine and coastal ecosystems;
- Studies on the interaction land ocean-atmosphere, for identification of better management practises;
- Marine biotechnology as means of adding value to marine-derived products;
- Studies on marine pollution and its sources, and of systems to reverse the effects;
- Establishment of effective and efficient surveillance of the sea and coast management;
- Use of ICT in diverse aspects of marine and fishery sciences, including remote sensing technologies for surveillance.

4.7 Construction

4.7.1 Introduction

Adequate housing is a primary need for everyone. Adequate housing implies the physical integrity of the building, the protection of the occupants from adverse environmental conditions, privacy, as well as access to clean water and other basic services in the context of a clean environment. A key input to adequate housing is the use of appropriate construction materials and techniques. Construction technologies are also important for improving Mozambique's road infrastructure.

There do exist in Mozambique sound construction practices, as well as successful traditional building techniques, and these constitute a solid base from which to effect improvements. Furthermore, there is a growing awareness concerning the need for adequate housing, and therefore an opportunity to build on the momentum through the application of S&T. Mozambique has considerable natural resources which could be exploited as construction materials through the application of research results.

4.7.2 Strategic Issues for Construction

The quality of housing in Mozambique needs to be improved, in particular to reduce vulnerability to natural disasters such as flooding. While a number of factors need to be addressed in this regard, including regulatory and legal, a key issue is the need to improve the

quality of materials used in construction, along with the application of appropriate construction techniques. Therefore research is required on local, low-cost construction materials and associated labour-intensive techniques, for both housing and roads.

The scope of activities of the present Engineering Laboratory of Mozambique (LEM) should be broadened to include research fields on low-cost construction materials and on water. Therefore, the focus of this institution should be adjusted accordingly; the focus should also include efforts for the dissemination of results, training and the development of skills.

The CRCTs should be at the forefront of stimulating research in this area, and promoting the resulting knowledge, technologies and techniques that are adapted to locally-available resources.

4.7.3 Construction Research Lines

Stakeholders from the construction sector have identified the following areas of focus for S&T research relevant to that sector:

- Research on house construction technologies and techniques, construction equipment suitable for different cultural and geographical contexts, and the adoption of related construction standards and regulations;
- Research into safety matters, reformulation and adoption of construction standards and regulations based on current local construction practices and conditions;
- Development of basic quality control criteria in the production and application of construction materials;
- Research into reducing the production costs of construction materials, and into low-cost materials;
- Research to identify the potential of locally-available construction materials, and to evaluate the socioeconomic viability of the use of such materials;
- Research into construction materials that reduce energy consumption.

4.8 Water

4.8.1 Introduction

Arguably, water is the most valuable resource on the planet. Water has unique scientific properties causing it both to be an essential prerequisite for all known life forms, and to dominate the mechanisms of the biosphere (whether as a solid, liquid, vapour or gas). Water covers 73% of the planet's surface and constitutes about 80% of the human body. It plays a wide variety of crucial roles at all levels of Mozambican society.

Water is essential for life and health, but it has also brought death, destruction and despair to many Mozambicans through floods, storms, disease and pollution. A wider appreciation of water and the many roles it plays in the lives of humans, animals, plants and the biosphere will empower Mozambicans both to value and to better manage this unique resource.

4.8.2 Strategic Water Issues

Mozambique needs to dramatically reduce the incidence and impact of water related disasters (floods, storms, drought, disease and pollution), and also to better utilise water as a renewable resource for irrigation, hydro-electric power, human consumption, manufacturing, waste management, transportation, and many forms of human leisure.

The management of sanitation and waste is often experienced as an unacceptable additional burden by impoverished communities, resulting in the neglect of essential sanitary practices. This leads to severe cumulative impacts in the form of disease (often fatal for the young), waste mountains, insect infestations, and environmental degradation.

There are many institutions that have activities in the water sector (such as education and research institutions, industries, and hydrographic basins management committees). Coordination between these institutions is necessary, in particular between those institutions that conduct research. The mandates, roles and responsibilities of each should be carefully formulated to ensure optimal and coordinated activities within the water sector. Specifically, the scope of the Engineering Laboratory of Mozambique should be enhanced to better coordinate research activities in the area of water and construction. Furthermore, efforts should be undertaken to promote communication and consultation between these institutions,

to encourage the development of a shared vision concerning water in Mozambique, and the needs for water research.

As water resources and the impact of water usage cross international boundaries, regional and international cooperation with scientific research institutions should be strengthened, for example within SADC and linked to NEPAD. This would also position Mozambique in the regional and international arena to benefit from and contribute to state-of-the-art science and technology, and standardisation efforts concerning water. Furthermore, there should be efforts to more effectively make use of rivers as sources of water, for domestic, industrial and agricultural purposes.

4.8.3 Water Research Lines

Stakeholders from the water sector have identified the following areas of focus for relevant S&T research:

- Legal and sovereignty issues related to water;
- Inventory of subterranean and surface water resources, their quality, quantity and potential use;
- Effective use of water resources, including rivers;
- The water cycle and its management;
- Purification and recycling technologies for water;
- Technologies and management systems for water in the industrial, domestic and agricultural spheres;
- Water conservation, including financial and political incentives.

4.9 Mineral Resources

4.9.1 Introduction

Mineral resources, including hydrocarbons, that exist in the country can contribute to economic growth and development through sustainable production, processing, local use and exports.

The innovative aspects of relevant applied technologies should be combined with local experience, knowledge and skills. Techniques and technologies that are environment-friendly should be investigated, to provide increased production and productivity. In addition,

techniques and technologies that add value to mineral products should be investigated. Some minerals can be of use for agriculture, for example, to improve of soil quality and in pest control, and therefore, contribute to agriculture production and development.

4.9.2 Strategic Mineral Resources Issues

A scientific research institute for geology and mineral resources should be established, to include the areas of geology (geology, geo-mechanics, seismology), mineral resources (safe, sustainable and low-cost technologies) and beneficiation (value adding to mineral resources). This institute would interact with other relevant sectors and would conduct research into the application of mineral products and by-products in industry.

4.9.3 Mineral Resources Research Lines

- Local processing of mineral products and hydrocarbons in order to provide for national demand and to increase the opportunities for export;
- Appropriate technology for small-scale and low-cost mining;
- The use of metallic and non-metallic minerals;
- The use of mineral products in construction materials;
- Exploitation of hydrocarbons for energy production and other uses;
- Applied geology and the environment;
- Application of geophysics in the mapping of water resources and in seismology research.

5 Strategic Crosscutting Areas

5.1 The Social and Human Sciences and Culture

5.1.1 Introduction

When dealing with communities there is a need to take into account several aspects such as their culture, habits and traditions. Thus the social and human sciences have an important role to play in community development in general, and the application of S&T for poverty reduction in particular. Scientific knowledge concerning a community's *modus vivendi* will facilitate the introduction of new technologies, especially as these relate to attitudes and behaviour.

The social and human sciences are basic instruments for understanding, interpreting and transforming the social processes that operate within societies, while keeping the human being at the centre of any change. Their use in a development context is indispensable. The social and human sciences are complementary to the natural and exact sciences, and at best, all work together in symbiotic relationship with each other.

The social and human sciences can contribute significantly to the development of a community's critical thought because they promote the ability to reflect on reality based on one's own context, as well as to encounter and grapple with other realities that may be culturally different. Moreover, the social and human sciences can contribute to an individual person's development through emphasising one's dependence on the community and society in which one lives, and combating an individualistic approach.

The social sciences also have a major role to play in innovation, by aiding the development of more holistic understandings of the problems and possible solutions. This is particularly true in the case of poor communities where "social innovation" has a major role to play. In this context, specific research capabilities in the social sciences should be developed to understand and strengthen approaches to grass-roots innovation.

A specific example in this regard, where significant gains are possible, is tourism, an important sector for the country's economy. The tourism sector has inherent crosscutting characteristics with regards to other sectors. Furthermore, the sustainable management of the environment in the context of a thriving tourist industry can be supported by the outputs of S&T. Thus, in this strategy, some of the identified research programmes include components that support the development of tourism, such as for the strategic areas of Agriculture, Environmental Sustainability and ICTs. In addition, Appendix 13 sets out example programmes and research lines for tourism.

5.1.2 Strategic Issues for Social and Human Sciences and Culture

The establishment of a research institute for the social and human sciences should be considered. Research results should be promoted for wide use by poverty reduction projects within the different strategic areas. In this way, respect for a community's habits and practices will be improved, and better ways of introducing changes in behaviours will

become possible, when new technologies are introduced, without damaging the *Moçambicanidade* identity.

5.1.3 Research Lines

Lines of research that should be focused on for the social and human sciences include:

- Social studies on the impact of socio-economic development programmes and of potential conflicts between modern and traditional approaches;
- Studies on the adoption and impact of the new technologies that are introduced within communities;
- Studies concerning community involvement in S&T-based measures related to diseases, water and sanitation.

5.2 Gender Equity

Women are significantly under-represented in the S&T system. While the causes of this may be several and varied, specific interventions are now necessary to redress this imbalance. An important component of the solution will be to encourage more girls to take basic science courses in secondary school, and more women students to enrol for science-related degrees at the tertiary level, so that there is a larger pool of women with S&T expertise that may work within the S&T system. However, traditional methods of education are effective in the medium and long term only. So specially-designed programmes should be implemented to enable women to gain the necessary S&T expertise, and also to fast-track women into playing significant roles within the S&T system.

5.3 HIV/AIDS

5.3.1 Introduction

HIV/AIDS is taking a big toll on the lives of millions of Mozambicans and it is a socio-economic problem of growing concern. The disease has harsh effects in vulnerable sectors such as education and agriculture, where reduction of the numbers of teaching staff and in the workforce for an economic activity threatens the availability of the human resources that provide the means of fighting poverty. The effects of the pandemic in other productive and social spheres are equally damaging. Therefore, the challenge for S&T in this area lies in addressing the important issues relating to the prevention and control of HIV/AIDS, while

devising interventions leading to preserving the human resource base which is crucial for implementing the plans to eradicate poverty and for economic development.

5.3.2 Strategic Issues

The overall aim of the MOSTIS in connection with HIV/AIDS is to minimise the setbacks to the quality of life of Mozambicans, to the economy, and to the pursuit of the development goals. Within this scope there are two inter-linked and complementary thrusts for S&T to address the HIV/AIDS pandemic.

- **Strengthening the existing national programme for the prevention and control of HIV/AIDS**

  This will be achieved, in the first place, by promoting inter-sectoral scientific research and collaboration within fields of intervention defined by the national policy, and detailed in the national programme for prevention and control, emphasising applied research in particular. The focus will be on:

- The development of a national research network for the promotion of scientific research on HIV/AIDS that will interact with regional and international organisations in the implementation of different research activities.
- Participation in nationwide communication and education activities on protection, risk factors and risky behaviour, through the preparation and presentation of materials from ongoing research (in the country and abroad) relevant to prevention activities, using modes of communication that are easy to absorb by the population.
- The strengthening of units for planning and monitoring of the epidemiological networks for reliable and comprehensive data gathering and analysis that will improve epidemiological surveillance and management, and allow adjustments in control strategies.
- Assistance in the devising of prevention and control packages targeting different population groups (youth, women, pregnant women, migrant labour, orphans, etc.), and methods to convey messages to these groups, in order to achieve and sustain progress in prevention of the transmission of HIV.
- Scientific studies of indigenous knowledge related to HIV/AIDS. This refers to, for example, the promotion of studies for the assessment of therapeutic properties of

local plants that are claimed to be effective in AIDS treatment, including the retardation of progression of the disease. The explanation of the processes and mechanisms behind the reported effects of such preparations and substances (whether from antiviral activity, from strengthening of the immune system or from activity against opportunistic pathogens, translating into a retarding of AIDS-related infections) would contribute to the search for alternatives to expensive treatments.

- Participation on vaccine trials, forming part of international research efforts into an HIV vaccine that are already underway. Candidate vaccines will require different phases of trial and validation. Promising candidates will require human testing under strict ethical controls. The work of integrated teams of national and foreign scientists should be promoted for the evaluation of judiciously selected candidate vaccines for local use.
- Improvements in early detection of infection, recognition and treatment of opportunistic infections, with the aim of increasing early diagnosis by combining improvements in testing methods with education initiatives that encourage voluntary testing. Research resulting in the development of fast and highly sensitive methods for early detection of the virus or markers of infection will improve the chances of early diagnosis and therefore of timely initiation of medical care and counselling.
- Training of staff in research techniques and methodologies.

- **Creation of new research opportunities in strategic issues for control**

  At present, economic constraints make treatment of HIV/AIDS prohibitive for millions of needy people in developing countries, including in Mozambique. Despite some initiatives to provide subsidised anti-retroviral drugs, these are still not affordable by many, this being one of the reasons for the focus on prevention in most resource-poor countries, including Mozambique. The large numbers of people already infected are resulting in substantial losses, both direct and indirect, in Mozambique's economy (by disease, death, depletion of workforce, decrease in production) and social suffering in families and communities (through orphaning and the disintegration of family structures and support). This calls for a broader-based

approach to HIV/AIDS, not only to prevent infection, but also to ensure large scale treatment in order to improve and lengthen the lives of those infected with HIV.

In view of the level of resources required, effective efforts in this regard may not be possible by a single country. However, with combined efforts from several countries, i.e. at a regional or international level, viable programmes of research may be undertaken. Therefore, integrated programmes of applied and strategically-targeted basic research should be fostered within the region and in collaboration with international laboratories and companies, aimed at controlling HIV/AIDS. Examples of such programmes would be:

- Evaluation and monitoring of retroviral therapy, involving step-by-step monitoring of the effects of therapy;
- Alternative therapies that are affordable by the poor;
- Evaluation of vaccines and adjustments of vaccine design to protect against locally-occurring strains of HIV;
- Developing a vaccine that is most suited to local HIV strains, where Mozambique has the role of contributing to the characterisation of local strains and their diversity;
- Generation of knowledge leading to the prevention and alleviation of HIV/AIDS, and related problems.

5.4 Environmental Sustainability

5.4.1 Introduction

Environmental sustainability refers to the meeting of human needs without reducing the ability of the environment to provide for those needs and support life in the long term. Sustaining the environment is a crosscutting issue that should be incorporated into all policies and strategies. In particular, attention should be paid to the management of natural resources, of waste, and of biodiversity.

5.4.2 Institutions and Governance

The environment is of interest to government, to all sectors of society and to all citizens. It is therefore important that researchers from different specialties, and working for various institutions, collaborate on activities that are related to conservation of the environment.

Furthermore, researchers or their institutes should promote the popularisation of their research results.

There currently exists a Centre for Sustainable Development, and the construction of the Centre for Research at Pemba is in progress. In addition, a Centre of Excellence should be established in order to pursue research in priority research lines. This Centre should allow researchers from different areas and institutions to participate in its activities, to facilitate the production of knowledge in a wide range of speciality areas. It should also set up programmes of collaboration with relevant international institutions.

To improve the coordination of environmental research, inter-institutional Technical Committees should be established for each research line (as has been done for Coastal Area Management), having the responsibility of advising the government's institutions (in this case MICOA and MCT) concerning the priorities of the programmes and projects in each research line, and to contribute to the monitoring and evaluation of these programmes and projects. The Technical Committees should arrange meetings and conferences to debate and review the programmes and their research results, as well as promoting the wide publication of the research results through appropriate channels, including web sites.

5.4.3 Disaster and Crisis Prevention and Management

Over the past 50 years, Mozambique has suffered a disproportionate number of disasters and crises which have severely impacted on its socio-economic development as well as the quality of life of almost all its citizens. There have been many natural disasters, such as floods, storms, droughts, starvation, infectious diseases (particularly HIV/AIDS, malaria and tuberculosis) and infestations.

There has always been a need not only to manage these crises and disasters, but also where possible to anticipate and prevent them, or at least to reduce their impact. Up until recently, and except in a very few cases, this has not been possible. Now, however, with a wide range of technologies and scientific analytical and modelling capabilities available, particularly ICTs (such as earth observation satellites), most of these problems can be detected or anticipated at an early stage, and their potential impacts, as well as possible preventative interventions, can be modelled and acted upon.

There are several global and regional initiatives that are building the capability to address these types of problems (such as GEOSS and SAKSS). Mozambique (though MCT) can partner and benefit from these initiatives, but it should also begin to build its own national, provincial and local capabilities so that they are fully compatible with, can benefit from and can support these multi-national applied S&T initiatives.

Finally, it is important that all communities be empowered with knowledge concerning the risks of natural disasters and measures that can be taken to reduce or nullify their impact.

5.4.4 Lines of Research

The lines of research that should be focused on for environmental sustainability include:

- **Coastal Area Management**

  The coast of Mozambique stretches for about 2 780 km. It is endowed with ecological resources that have recognized international value, and it includes important population centres with associated development activities, protected by several institutions. So it is an area to protect and at the same time an area to explore with a view to promoting the development of Mozambique.

- **Urban Environment Management**

  The urban centres are areas of population concentration and development activities, and thus they area areas where the quality of the environment and of human health may be degraded.

- **Conservation of Natural Resources**

  Despite the considerable natural resources that Mozambique has, it is classified as one of the poorest countries in the world. This is partly because the exploitation of the natural resources has not been based on scientific data nor has there been use of appropriate technologies. There is a need to publish information on the status of Mozambique's natural resources, on relevant indigenous knowledge, on the sharing and conflicts related to access to the resources, and on appropriate technologies for exploitation of these resources.

- **Climatic Changes**

This research line will become increasingly important as scientific studies indicate that extreme events like droughts, cyclones and floods will increase in frequency and intensity, as well as the resulting impacts. Adapting to these changes will require a combination of global scientific knowledge and knowledge specific to Mozambique.

- **Environment and Poverty**

  Poverty, which finds expression as a lack of knowledge, abilities, materials and financial resources related to the use of natural resources, is a key factor in recent patterns of environmental degradation. Studies of the relationship between poverty and environment should therefore be made.

- **Environment and Economic Impact**

  Research is required into methods of evaluating and expressing the economic impact of decisions taken in relation to the use of natural resources.

5.5 Ethno-botany

5.5.1 Introduction

Ethno-botany is a highly inter-disciplinary area of research, combining both the natural and social sciences, and overlapping with several existing disciplines and areas such as botany, biochemistry, health and traditional medicine. It investigates the traditional interaction between people and plants, with a view to applying such knowledge to many areas of Mozambique's society and economy. Such research focuses on the identification, naming and classification of plants (and related standardization issues), their place in indigenous knowledge, their value, and their use and management.

This approach presents an opportunity for the scientific, commercial and industrial development of new products and knowledge from existing but unexplored indigenous knowledge and experience. Indigenous knowledge of plants, combined with scientific knowledge, may be harnessed towards economic and other benefits. The comparison and integration of findings from both indigenous and scientific knowledge may results in benefits for the sustainable exploitation and conservation of plant diversity and for development. The interdisciplinary nature of ethno-botany can lead to a more participative seeking of solutions for local problems.

Ethno-botany promotes a systemic approach to exploiting plants to the benefit of human society. In this respect, conflicts in approach can arise between traditional healers and traditional medicine on the one hand, and Western medical practice on the other. A good example of this is the approach to dealing with HIV. In contrast to a Western clinical and pharmaceutical approach, ethno-botany looks at plant derivatives, especially in their social context, to achieve results in retarding the progression of HIV in a patient.

5.5.2 Institutions and infrastructure

Research and training activities related to ethno-botany are undertaken by a wide range of institutions, including research institutes, HEIs (both public and private) and private research establishments. The activities of these institutions include establishing databanks, cataloguing plants, promoting the production of some of the plants, and characterisation studies on plant health, and chemical and biological properties. In addition there are several associations of traditional healers that are practitioners in the area of ethno-botany. Nevertheless, ethno-botany is not yet a well-developed discipline. There is a need to bring coordination and coherence to the field, and therefore mechanisms should be established to coordinate activities in this field, to define research priorities, to promote ethno-botanical research, and to regulate the research.

5.5.3 Strategic Issues

A significant aspect of ethno-botany has to do with indigenous knowledge concerning local plants and their uses in different contexts. Collating and codifying this knowledge is essential. Furthermore, there is a need to protect the value of such knowledge and address the issue of Western companies obtaining traditional knowledge and then patenting it, without building in fair returns to the communities from which the knowledge was gained. A much more equitable IPR regime for the use of indigenous knowledge, including traditional plants must be established, and this is particularly the case in less developed African countries where rural populations are ill-prepared to deal with the intricacies of Western practices related to IPR, such as TRIPS. Particular efforts should be made to protect the interests of the local communities from which the indigenous knowledge is derived, and at the same time, to promote the sharing of knowledge amongst poor communities so that all may benefit in sustainable ways.

Due to its multi-disciplinary nature, there is also a need to collate information related to ethno-botany into an information base for sharing and dissemination. Such an information base would include information about work being undertaken or completed, the researchers and institutions involved, and relevant materials and equipment available.

In recent years the Western world has shown renewed interest in plants as sources of pharmacological compounds. This interest is fuelled by the discovery of new active molecules by the pharmaceutical industry, and by adoption of alternative medicines based on use of plant parts or extracts by the public. There could be benefits to Mozambique if local plants with medicinal properties were better characterised and validated scientifically, along with parameters for quality control and consumer safety.

A research centre for ethno-botany should be established to promote and coordinate research activities, to deal with the conservation of natural resources (plants), to interact with other institutions, and to define priorities for and the application of legislation**.** The institution would assess the market for, and promote the production of, plant-based products by small, medium and large scale enterprises.

A major area of contribution by ethno-botany is in the area of health and healing. There is scope for research into treatments for neglected diseases, such as diarrhoea and schistsomiasis, and for hypertension and diseases of the eyes, as well as research into the nutritional value of local foods, and the quality standards that should be used in exploiting their commercial value. In general, there needs to be an approach to health and healing in Mozambique that balances traditional knowledge of medicinal remedies with Western medicine.

There are other opportunities for exploring an ethno-botanical approach. For example, aromatic plants can be used for oils and perfumes and aroma-therapy; ornamental plants may be highly prized in urban areas, resulting in a source of income. There are as yet unexplored maritime botanical resources. The challenge lies in enabling communities to realise that local resources that may be freely available in their area may have commercial value, and then enabling them to benefit from such value. The CRCTs should be tasked to play a role in this area.

5.5.4 Lines of Research

The lines of research that should be focused on for ethno-botany include:

- Research into the characterisation of traditional practices, including social aspects;
- Research to validate traditional knowledge;
- Research into the use, production and commercialisation of products based on ethno-botanical knowledge.

6 Enabling and Crosscutting Technologies

This section addresses areas that need further strengthening in order to act as boosters of the country's development, namely ICTs and Biotechnology. ICTs can create a favourable environment and may acts as a catalyst in bringing new dynamics to the development of all the other areas.

6.1 Information and Communication Technologies

6.1.1 ICT Capacity Development

To enable Mozambique to become an information-literate nation, and the development of Mozambique as an Information Society, an extensive capacity development programme needs to be developed covering a wide range of ICT skills and skill levels. The growth in the use of ICTs for development is currently stunted by the insufficient supply of appropriately trained, qualified and experienced people. Beyond formal academic education, courses need to be developed for designing and developing ICT applications for promoting information literacy for all, for building awareness of the potential benefits, for training ICT trainers, educators and content developers, as well as for developing software applications and for maintenance and support skills.

It is particularly important for the poorest and most remote communities to be exposed to ICTs, both for access to knowledge and services, as well as for promoting ICT literacy. Learners and teachers ought to be empowered to choose the most appropriate ICT applications and content packages for their needs and specific context, and should also learn the necessary ICT skills as a by-product of using applications addressing the direct need. Training programmes should take into consideration regional, cultural and linguistic differences, educational levels and societal roles of men and women, and target the needs of youth and illiterate citizens.

ICT curricula need to be introduced at all levels of the education system, from primary to higher education, as well as through professional training centres. They should focus on providing basic skills, and an understanding of the role of ICTs in creating sustainable livelihoods. The focus of the curricula should be on not only proprietary applications, but also on Free and Open Source Software (FOSS) applications. For the rapid adaptation of ICTs and training of future generations, a broad-based primary and secondary school ICT access programme needs to be established to secure early exposure to new technologies. ICTs can in the short and medium term reduce the lack of access to education at all levels, when used as tools for distance learning. If established as learning channels, they have the potential to act as a means of learning throughout an individual's life, and to enable options such as on-the-job training and distance learning for many Mozambicans. The lack of highly skilled ICT professionals should also be tackled under the umbrella of the Mozambican ICT Institute (MICTI). MICTI should function as a centre of excellence for ICT capacity development in the country and as a hub for providing support to ICT professionals.

6.1.2 ICT Infrastructure and Access

The costs of ICT-based services, knowledge resources and the Internet are too high, owing in part to existing technologies and service providers. Therefore, the strategic planning and deployment of a national ICT backbone, as well as access methods, is crucial for the rapid mainstreaming of ICTs within the national development agenda. Development of ICT infrastructures should be a national objective, towards which all major infrastructure projects should contribute. When building new roads, railways and power lines, fibre optic cabling should always be included as a component of these projects, thus contributing to the extension of the national backbone. Through cross-sector collaboration and efficient coordination, infrastructure costs could be substantially reduced. Infrastructure is accessible only if service costs are in line with the financial resources available to users. As in many developed countries, costs for high-quality broadband are not affordable to a majority of users. TDM should promote business models supporting low-cost connectivity and universal access.

The Government's policy and strategy for universal access is one of the main national projects to extend access to rural, as well as economically viable, areas. This reflects the Government's commitment to introduce and make new communication technologies

accessible to all citizens, regardless of their living location. In this regard, wireless technology offers potential solution for low cost connectivity. There is R&D being conducted in the country and abroad, with potential to lead to low cost access for users.

End-user access to equipment (such as computers, monitors and printers) remains a major challenge in Mozambique. The costs are beyond the average citizen's reach, which calls for seeking and implementing low cost services and solutions. The promotion of these services and the adoption of ICTs can be encouraged and speeded up through tax reduction and exemption measures.

Facilities for accessing ICT-based services by the general public are not common in Mozambique. SchoolNet sites, Provincial Digital Resource Centres and Community Multimedia Centres provide access points for only a very limited number of people. Expansion of these centres to all parts of the country should be a top priority, as these centres will function as spearhead initiatives for introducing ICTs to various regions in Mozambique. Innovative access mechanisms and low-cost access providers need to be identified to secure sustainability of these initiatives. Well-defined business models are needed, and subsidy schemes should be considered along with public-private-partnerships. In addition, further exploration is needed of innovative combinations of modern digital technologies and low-cost conventional technologies, such as combining Internet access with broadcast radio technology.

6.1.3 Common Architectures and Platforms

Common ICT architectures and platforms are a prerequisite for sustainable and scalable development of a national ICT infrastructure. ICT architectures include standards for databases, applications, networks, hardware, protocols and interoperability. A well-defined and nationally-adopted architecture provides a basis for sector-specific ICT strategies and secures scalability and flexibility of implemented solutions.

Another dimension that is required is the definition of a national infostructure. An infostructure refers to a standardised vocabulary and description of key government and process-related data, such as about citizens and health. Once defined, collaboration between institutions and sectors becomes vastly more efficient and the development of integrated services and the streamlining of government functions becomes feasible. A well-integrated

government apparatus also provides the foundation for efficient decentralisation and for building efficient and transparent services.

A functional ICT platform allows centralised management of ICT infrastructure and applications, as well as the introduction of elements of cost reduction, such as a government-wide data centre and software standards. Common standards ensure increased security and give a competitive edge in procurement of ICT equipment and software based on framework supply contracts.

6.1.4 ICT Entrepreneurship

The private sector has a fundamental role in providing support to the expansion of the ICT sector in Mozambique and defines the need and skills requirements for the ICT workforce.

For Mozambique to develop a viable ICT sector, government needs to create a facilitating environment. The establishment of a free trade zone, and tax and duty exemptions for ICT software and hardware producers, should be considered. Incubator mechanisms, such as are found at MICTI, for sharing common resources, for accessing financing and for promoting the benefit of peer-to-peer support, are extremely important for developing entrepreneurial skills, especially in the SME sector.

The improvement of internal processes and quality control systems to meet international standards is needed to enable better integration of Mozambican ICT enterprises in the regional economy, and as means to attract foreign investment and clients. Such quality improvements and the development of management skills should be a priority to ensure successful engagement in regional and global markets.

Government should also promote collaboration between scientific institutions and private enterprises working in the area of ICTs. Tighter cooperation would result in a better match between academic education and private sector needs and would provide access to leading research and international experience for the private sector.

6.1.5 Technology Acquisition

For the successful involvement of ICTs in national development, appropriate technologies that are conducive to development need to be selected and promoted. In particular, both the options of proprietary application technologies and open application technologies (FOSS)

should be considered. Technology acquisition policies should take into account the need to develop and nurture local capabilities and capacities, and open and standard interfaces need to be maintained to flexibly cope with the evolution of technologies. ICT solutions need to be robust against technological change and allow rapid and low-cost scaling-up. Lessons from developed economies reveal that ill-planned structures and excessive dependence on technology without standards become a hindrance to development.

6.2 Biotechnology

6.2.1 Introduction

Biotechnology is a prime example of a crosscutting technology that has enormous potential to add value to a range of products and services in different sectors. It is a technological platform that combines different scientific disciplines to generate alternative solutions to, amongst others, food production, human health, and industrial and environmental problems. It contributes to the current rapid developments in sectors as agriculture, medicine, the environment, marine biology, the processing industry and biomaterials production worldwide. For example, biotechnology has the potential to provide practical solutions to needs such as: a) increasing production efficiency, b) improving the nutritional qualities of food crops; c) developing crops resistant to diseases, pests and adverse conditions; d) simplifying rapid diagnosis of diseases; e) new medicines and vaccines for the treatment and control of disease; f) biological processing of industrial products; g) methods for managing polluted environments and for reversing environmental degradation.

The rapid evolution of biotechnology in the developed world is bound to have an impact on policies and choices in Mozambique sooner or later, so there is a need to prepare for inevitable changes. The fact that biotechnology products have entered world markets and are making their way into the food production and supply chains in developing countries is not to be ignored. While offering a wealth of possibilities, biotechnology, as any new technology, can raise fears and concerns that the benefits promised may be associated with risks to the environment and to consumers. As well as awareness about the benefits, stakeholders and the public need to be enlightened about the downsides of improper applications of the technology.

Mozambique's current capacity in biotechnology is extremely limited. Changing this situation requires strategic commitment of resources for this area, so that its potential can contribute to development. In addition, Mozambique can contribute to institutions and networks in the SADC region, to better address long term goals related to food security, health, environmental sustainability, economic stability and development. Therefore a specific biotechnology strategy for Mozambique should be developed.

6.2.2 Biotechnology for different Sectors

Biotechnology is an engine of technological development in many different sectors. Three examples are given as follows:

Agriculture

The current options to increase agriculture production rely on soil and water management, control of diseases and pests using pesticides and herbicides, use of improved varieties of crops and plants, in some cases with intensification driven by mechanisation. Practices aiming at improving productivity of farming by smallholders have been limited, and there is a need for interventions to enable small-scale farming to play a more active role in sustainable food production. Biotechnology has been shown to enable maximised production, increased in the quality of produce, correction of soil deficiencies, as well as the generation of crops resistant to pests, diseases and extreme conditions like drought, salinity and soil toxicity. The adaptation of cultures to extreme conditions (such as species tolerant to salt that can be grown in soils with salinity problems, or species tolerant to drought that can be grown in dry areas) can allow the use of lands that would otherwise be unsuitable for agriculture production.

Medicine

A number of diseases and malnutrition problems are major concerns to the health of the population. While the first line of defence against these lies in the areas of public health and primary health care, the use of drugs, antibiotics and vaccines to control diseases such as malaria, tuberculosis, polio, measles, diphtheria, tetanus, whooping cough and internal parasites is also necessary. However, organisms such as malaria parasites and bacteria develop resistance to medicines, a situation calling for different thinking to solve the

problem. Diseases such as HIV/AIDS have entered the scene, presenting a challenge to social and economic development.

Mortality from infectious diseases still takes a toll in vulnerable populations and age groups. In addition, expansive and emerging epidemic diseases are appearing, with characteristics beyond the traditional common illnesses. Dealing with diseases such as the threat of highly pathogenic avian influenza, requires thinking beyond borders regarding transmission and control, with efforts involving international collaboration in different fields, and the need to explore alternative approaches.

The decoding of the human genome is allowing the study of the functions of many genes, and leading to the understanding of the involvement of genes or molecular mechanisms in pathological processes and diseases. The understanding of the biology of pathogens, their transmission, host resistance, the genetic basis of disease, the mechanisms of pathogen resistance to drugs, among other issues, is relevant to determine adequate strategies to control diseases. In this regard, biotechnology is enabling a shift in the approach to diseases and their control. New and accurate methods to detect diseases are being developed, new therapies and techniques to generate vaccines are being devised as solutions to intervene in disease control. Genome sequences are available for a number of viruses, bacteria and parasites that cause diseases in humans, including the tuberculosis bacillus and the malaria plasmodium. In particular, for these pathogens there is need for investigations on the biology and behaviour of local strains, in addition to the research that is ongoing internationally.

Most of the answers will come from international research, but it is important that Mozambique's research contributes, in order to ensure that the generated solutions will be applicable locally. For example, strain variation in a pathogen can render a vaccine that is used in the developed world unsuitable for protection against local strains. In general, the biotechnology studies in Mozambique should aim at the generation, interpretation and use of genetic data of humans and pathogens to understand diseases and to devise ways to deal with them.

Industry

The material and industrial processing sciences are gaining ground, as biotechnology is applied to the production of materials and to processes. Many materials used in industry are

dependent on the availability of natural resources, for which there is a finite supply. There is therefore a strong incentive to investigate alternative ways to produce critical materials, and thus to develop systems for biological processing. The final stages of the processing chain for such materials can most easily be studies in developed countries that have the necessary production technology in place. However, countries such as Mozambique can play an important role in the initial stages of the processing chain, by identifying the array of potential sources of materials, or of organisms for biological processing, both of which are in much more varied supply in the rich ecosystems of the developing world. For example, biomimetics seeks understanding by studying the way nature solves basic problems. The core approach is to imitate the processes occurring in nature in a controlled environment, in order to understand how they work, and then apply a suitable technology like biotechnology to reproduce the process or devise a product. In this regard, the functions of certain organisms are uncovered, and these can be used for production processes like fermentation and purification of compounds. Initiating the inventory of such resources in the country could lead to potential developments, in partnership with research institutions and companies abroad.

6.2.3 Institutional Challenges

Due to biotechnology's crosscutting nature, the challenge it presents is one of mobilising various sectors around the use of a common approach to address different types of problems. Because it is a new field of study in Mozambique, biotechnology capability is developing in several centres as they respond to the need and opportunity. However, without intervention, this trend will result in a dilution of resources as different sectors try to marshal their resources to address the need, but without coordination or communication between the different entities involved. While it is true that the need for biotechnological applications varies depending on the sector, it is also true that most of the approaches would share common methodologies. Therefore an optimal strategy would be to integrate, as far as possible, activities that are based on common methodologies, and also for some institutions to specialise.

The organizational system should evolve from the already existing institutional nodes where biotechnology activities are performed. Other nodes with specific orientations and mission should be established in different parts of the country, based on local requirements to

implement the biotechnology strategy. These could be biotechnology units, linked to biotechnology centres, which together with existing biotechnology centres and capacity would form a networked Centre of Excellence (CoE) for biotechnology across Mozambique. There should also be mechanisms to make resources available to researchers from different fields.

The CoE would be under the direction of MCT, who would deal with coordination, overview of the activities ongoing in the field, and resource allocation. The institutions in the CoE should have defined missions and priority research areas, based on policy guidelines emanated from MCT, in consultation with different sectors.

6.2.4 Lines of Research

Lines of research that should be focused on for biotechnology include:

- Adaptation and application of current knowledge and technologies generated in developing countries for improvement of the productivity of subsistence crops and livestock breeds;
- Alternative technologies of land management for agriculture and livestock production;
- Characterization of genetic markers of relevant traits of local food crops and animal breeds, for selection and breeding purposes;
- Identification of determinants, major pathogens and vectors of high-impact diseases of humans, animals, plants and marine species;
- Application of existing (and development of new) molecular detection and molecular epidemiology methods to support the control of disease;
- Development and testing of new generation diagnostic assays, therapeutic and prophylactic products, derived from gene technology;
- Evaluation of the diversity of Mozambique's biological resources;
- Research on mechanisms of disease infection and protection in humans and animals, and mechanisms of resistance and adaptation in crops and plants that are important locally;

- Risk analysis of biotechnology-related solutions.

7 Creating a Culture of Innovation

7.1 Innovation for All

In the context of industry and a developed market economy *innovation* may be defined as *the process by which new products and services enter the market and the creation of new businesses, thereby providing the engine of economic growth and wealth creation*. This definition, however, does not allow for innovation outside an industrialised setting, for example in the informal sector or within a community caught in poverty. In Mozambique a sizable portion of the population has or will have little direct interaction with the market economy over the next few years. Yet innovation is both possible and desirable in such settings so that people may take responsibility for their own development. An alternative definition of innovation in this light is: *Innovation is the process and the outcomes by which individuals and groups devise new ways to solve immediate problems and improve their quality of life*.

Using these two alternative but complementary definitions of innovation for the Mozambican context, a culture of innovation may be characterised as one in which:

- The relevance of innovation to the improvement of the quality of life is understood and appreciated at all levels, and across all sectors;
- Individuals at all levels of society are fully aware that they themselves can and ought to be involved in innovative activities;
- An entrepreneurial approach to life and work is expected.

7.2 S&T in Society

Society is segmented into the public sector, the private sector, NGOs and CBOs, etc. These segments are further subdivided into economic sectors (such as agriculture, mining and fishing) and into organisations, departments and so forth. However, the major economic, social and developmental issues that many societies face, including Mozambique, are not segmented along these lines. This represents a major challenge for agencies such as MCT who are responsible for effecting development within society.

In addition, the interdependency between STI and society must be recognised. Conditions that encourage the growth of STI can be created by society through its governance structures. The STI that is thereby strengthened will in turn impact society, resulting in an environment that is even more favourable for the harnessing of STI. The efficacy of policy and strategy can be enhanced by recognising and exploiting this cycle of interdependence. Furthermore, STI is inherently a crosscutter, and the scientific approach is applicable to a very wide range of problems and circumstances.

Therefore development initiatives should follow holistic and coordinated approaches. In particular, holistic and coordinated approaches are necessary for STI to be fully harnessed in the service of Mozambique's priorities. All segments in society, and specifically all government ministries, should recognise the important role that STI has to play in enabling them to achieve their priorities. In addition, they should recognise the need for coordination of STI initiatives across the segments, so that holistic approaches are fostered.

MCT should play a leading role in promoting a national debate on these issues, and in enabling all government ministries to appreciate the fundamental role of STI within their own mandates.

7.3 Mozambican Culture

Culture has to do with a way of living. It is expressed through everyday habits, uses and customs. It is also a source of national identity. In creating a culture of innovation, it is therefore important to take into account Mozambican culture. This represents a huge challenge for the country: to introduce into communities and other segments of Mozambican society research findings, the application of technology and the uses of innovation in ways that are culturally appropriate. A key aspect is to be cognisant of, and undertake research in, the cultural values of Mozambique's different communities.

7.4 Grass-roots Innovation

The concept of grass-roots innovation seeks to embody this approach to innovation and a culture of innovation in a way that is particularly relevant to those caught in poverty. The point of departure is the belief that all people, even the very poorest and least educated, are born with the ability to innovate, even if that means having useful ideas based on "common sense" to deal with everyday challenges.

Innovations imposed by outside agencies (top down) to foster development within poor communities have been tried repeatedly with little success. Since the poorest and most remote people are intimately familiar with their own context, it is to be expected that their ideas can be turned into innovations and hence into solutions to their problems. Therefore, local and indigenous people with ideas should be encouraged to view their ideas in the context of a process of innovation, and to use a scientific approach to assessing potential solutions, selecting a preferred solution, and planning and implementing it. The social sciences in particular have a role to play in facilitating the use of the scientific approach within communities, and in the adaptation and adoption of technologies.

While formal training in S&T or ICT is not an essential prerequisite for engaging in grass-roots innovation, they hold the potential for taking such innovation to the next level of implementation and diffusion. Hence, S&T and ICTs need to be introduced to indigenous innovators early on in the innovation process in a way that avoids alienating them from the very process in which they are engaged.

There have been few attempts to bring the findings of the latest research to the poorest communities, and in a format that they can quickly and easily access and assess. Few examples exist of researchers building close relationships with people in the poorest communities for whom there could be significant potential for benefits (direct and indirect) stemming from their research. Yet, when such linkages have been made, for example in the agricultural sector, significant innovations can result, demonstrating the value of bridging the communication gap between researchers and subsistence farmers through mutual understanding. Those in impoverished communities should be encouraged to view innovation not simply as a means to make more viable a way of life based on mere subsistence. Instead, wealth creation, even on a very small scale, should be fostered as a realistic goal that can be achieved through an innovative outlook and the exploitation of technology-based solutions.

When ideas and innovations from poor and remote communities are being sought, it is likely that some members of those communities (particularly the older men) will be favoured, even if subconsciously. However, innovative ideas are more likely to come from young minds (i.e. youth, both boys and girls), and from people with a strong group culture (such as women). Targeting these groups is vital for a successful development of an innovation

culture, and as a starting point in adoption of innovative ideas. Solutions devised with the direct participation of these groups are apt to be easily accepted and widely adopted. Special attention should be given to inclusion of women, as they have an active role in the management of subsistence agriculture.

7.5 Awareness Building

All individuals need to be made aware of the potential benefits of STI in their own context. However, to provide a framework within which to focus resources for awareness building, there are three priority groups: policy makers, youth, and the poorest and most remote communities.

Awareness building mechanisms such as Science Festivals, science bazaars, shows, guest lectures, broadcasts, web sites and road shows are important and valuable for building a culture of innovation, and they should therefore be used. However, the different limitations of all these mechanisms must be recognised, in particular, their limited ability to serve remote communities.

Researchers are fairly good at communicating with their colleagues concerning scientific information, and even with those members of society that are aware of the importance of S&T. But they need to find alternative, proactive mechanisms to reach policymakers, youth and remote communities.

All people are capable of comprehending complex systems (the natural environment being one) if they are presented to them in terms compatible with their worldview. It must be assumed that most people in the poorest and most remote communities are functionally illiterate. Therefore a visual presentation should most often be used, supported by additional tactile and/or audio material in the local language.

Visual representations can be in the form of video, simulations, animations, and graphics. Such visual presentations usually lend themselves to further tactile interventions by the observer/learner. In the past such presentations could be offered only in person, but the digital revolution now allows the use of an enormous variety of combinations of the most appropriate media, depending on the communication required.

In order to produce such digital material, researchers themselves need first to recognise the importance of communications with this group of stakeholders. Second, they

need appropriate training, assisted by relevant specialists (in, for example, pedagogies, ICTs, multi-media).

7.6 Collaborative Community Development Processes

Many of the problems and opportunities that present themselves to those in poverty in Mozambique can be much more effectively addressed through harnessing the potential of S&T, and especially if a collaborative approach is followed. There is great power in analysing a problem in a group, and similarly, a group implementation of a solution will usually be more effective. A scientific approach relies on the self-correcting mechanism that is an inherent part of a group in which each individual is making an active, but complementary, contribution. In this way, local problems and advantages can be identified and analysed optimally, and effective actions designed and implemented. Examples of initiatives that would benefit from this approach include wealth-generation schemes such as agro-processing, the building of storage dams, irrigation systems, dykes and crop storage facilities, and the provision of transport and farming equipment.

7.7 Making Knowledge Available to All

There are several areas where knowledge derived from S&T research on "good practices" exists in Mozambique, but it has yet to be made available to the key stakeholders (decision and policy makers, as well as subsistence farming communities). These areas include: building materials, crops, livestock, water conservation and sanitation. Interactive, multimedia environments would be ideal for this purpose (especially CD-based).

Knowledge is an essential requirement for development. Critical questions need to be answered: what are the key drivers for such development? What types of investments, and policy and institutional reforms are needed to reduce poverty and hunger? How and where should desired reforms and interventions be focused? How well is the current portfolio of interventions performing? Are these on track to meet the MDGs? What value would be added through policy harmonization?

Finding credible and locally relevant answers to such questions requires adequate access to information, knowledge, analytical tools and capacity. For the information to be useful, it must be timely, relevant and accessible to a wide range of policy makers, development practitioners, and beneficiaries. Moreover, by sharing knowledge collectively at

a national and multi-provincial level, economies of scale and mutual learning through the exchange of knowledge and experience can be encouraged further, while promoting greater transparency, harmonization and peer-review in the formulation, implementation, monitoring and evaluation of future strategies.

To address these requirements integrated knowledge support systems for development should be established that pull together a virtual community of experts, specialists and practitioners from multiple disciplines, drawn from across the country, and including some international experts. The knowledge support system would focus on a particular domain (such as agriculture) and should include an infrastructure of information and knowledge bases, and tools to analyse the information, thus producing new knowledge, with ways of making it easily accessible and useful to a wide range of practitioners, policy makers and other users in the chosen field of interest.

A national ICT-based platform needs to be developed for providing knowledge management services especially in the area of STI. This platform would function as the integrator of innovators and promote collaboration between private sector enterprises and scientific institutions. This platform would also provide access to content for scientific capacity development for students and teachers at all levels and within all geographic regions, and would provide solutions for inadequate STI training capacities in remote areas. It would also introduce a channel for regional and international exchange of experience.

8 The National S&T System

8.1 Description

The national S&T system consists of a range of entities and organisations that are legally established to operate in Mozambique, from both the public and private sectors, which are described and depicted in a simplified form as in Figure 9.1.

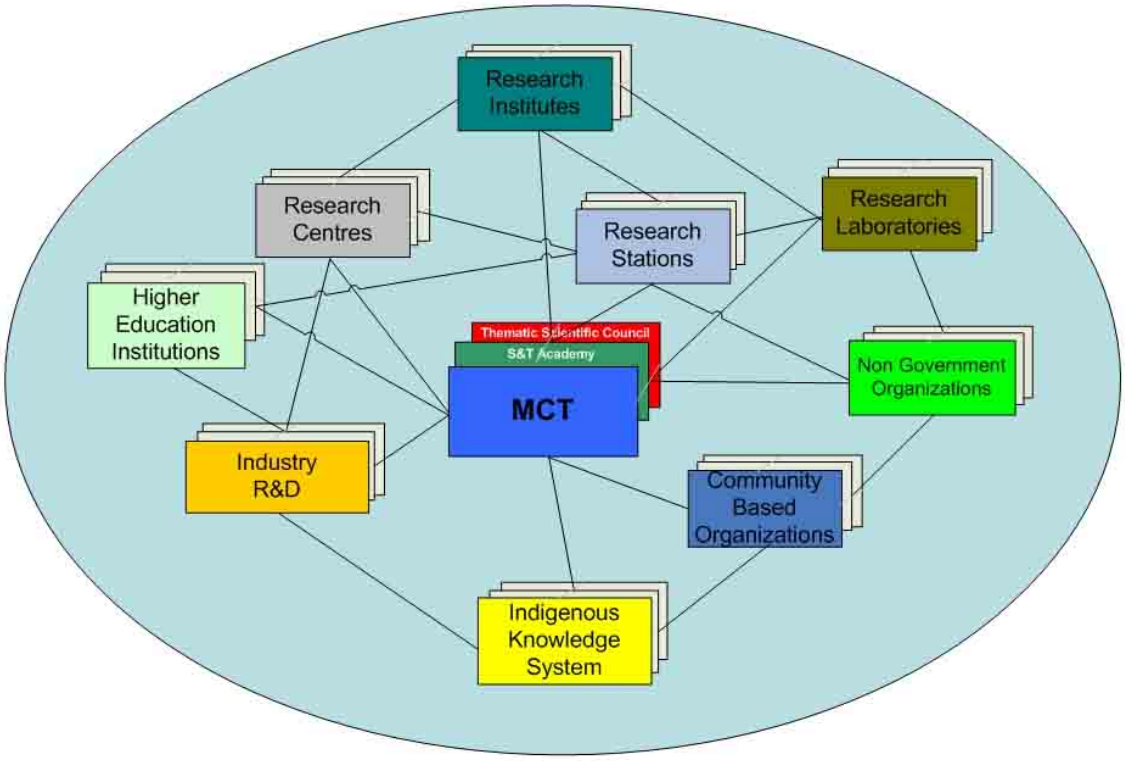


Figure 9-1: Mozambique's National S&T System

- Organisations that create new knowledge through R&D, including:
  - University research units
  - Research institutes, centres, stations and laboratories
  - Private sector companies doing R&D (often product and process-related)
- Institutions that develop human resources with S&T expertise:
  - Public higher educational institutions
  - Private higher educational institutions
- Institutions that provide financing:
  - Research funds

    - Local representatives of international funding partners and instruments
    - Venture capital funds for funding start-up companies
- Institutions that facilitate the creation and growth of innovation-based companies:
    - Science parks
    - Incubators
- Government ministries:
    - MCT
    - MEC
    - Other line ministries with S&T functions
- Other entities
    - The Thematic Scientific Councils
    - The Science and Technology Academy
    - Non-governmental Organisations (NGOs)
    - Community-based Organisations (CBOs)
    - Indigenous Knowledge Systems (IKSs)

For purposes of simplicity, only three blocks are shown in each set, when in reality there could be many more than three institutions of a particular type, and furthermore, not all types of institutions in the S&T system are shown in Figure 9.1. The lines between the blocks represent the relationships between the different institutions. The nature of these relationships can vary depending on the type of institutions involved. Thus what the lines represent includes reporting, coordinating, regulatory and cooperative relationships, that may be expressed through government regulation, formal Memoranda of Understanding, participation in joint meetings and committees, or informal relationships between individuals. Again for purposes of simplicity, not all relationships have been shown in Figure 9.1. For each area of research, such health or agriculture, there exists a subset of the national S&T system, consisting of the institutions whose activities are focused on that particular research area, along with some institutions that are common to multiple research areas such as MCT. The S&T system should also be understood to include the policies and governing frameworks that enable and regulate it.

8.2 The Roles of MCT and other Ministries

MCT undertakes its functions as described in Presidential Decree no. 17/2005 of 31 March 2005, covering three primary roles: (1) policy making for S&T, (2) monitoring of the performance of all scientific research by the public sector, and (3) coordination of all S&T-related activities within the public sector. Thus, MCT establishes an enabling environment for development of science and technology, while the line ministries are responsible for the implementation of research activities and S&T-based interventions. In fulfilling its role in the implementation of the strategy, MCT will exercise an overall managing function, and will be appropriately involved in the planning of programmes, follow-up, monitoring, and in evaluation. At a programme level, MCT will be directly responsible for research activities, while line ministries will be responsible for roll-out and implementation. It will be important to avoid competition between ministries during implementation. Instead, a team approach should be followed, in which the baton of responsibility is passed from one ministry to the next at the appropriate time during the lifecycle of an intervention.

By its nature, S&T is a crosscutting issue that is relevant for all sectors (depicted in Figure 9.2), and this underlines the need to ensure that S&T is mainstreamed within each vertical sector. MCT should encourage such mainstreaming efforts in partnership with each applicable line ministry.

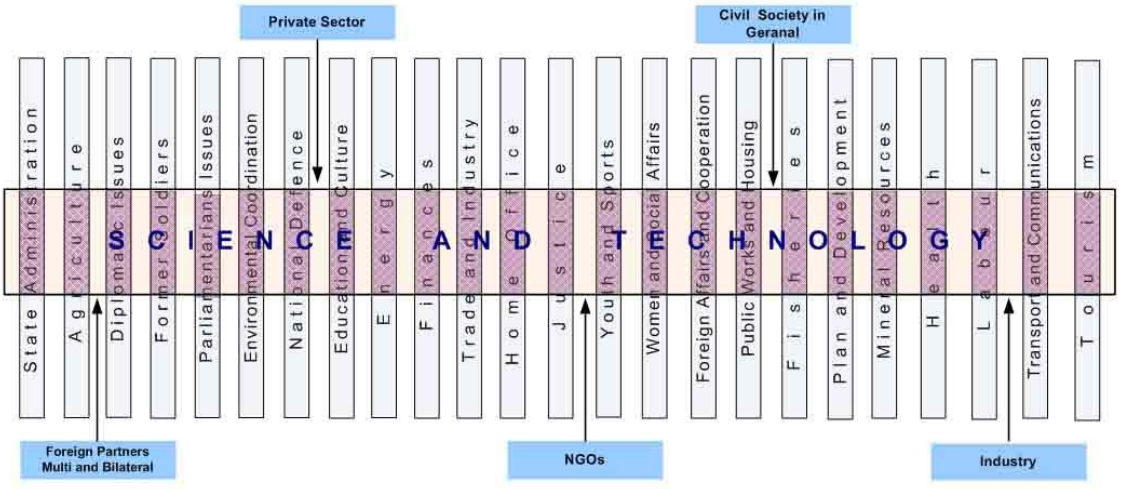


Figure 9-2: The Role of MCT as a Crosscutter

The crosscutting nature of MCT's role requires that careful attention be paid to the areas of intersection between MCT and each relevant line ministry. Line ministry S&T

activities will be dealt with through memoranda of understanding between the concerned parties. To ensure the greatest possible clarity of roles concerning S&T activities in a particular sector, the respective roles of the two ministries should be clearly understood in relation to the full lifecycle of an S&T-based intervention. In general, MCT is responsible for research and development, while the line ministries are responsible for implementation in their respective sectors. Thus, an intervention may commence with research performed under the direction of MCT, which leads to a potential solution to a problem in a particular sector. The solution may then be tested through a pilot implementation within the sector, with the cooperation of the applicable line ministry. If the pilot is successful, then the next phase is adoption of the solution by the community. Once adoption has taken place, the intervention will be fully in the hands of the line ministry. To ensure alignment between the two ministries, and a smooth and effective handover between MCT and the line ministry, staff from both ministries should be involved in the intervention from the start. As the most difficult phase is the transfer of responsibility from MCT to the line ministry, it should be the subject of careful planning and effective management.

8.3 Organisation of Research Areas

R&D is organised in Mozambique into research areas, lines, programmes and projects, as depicted in Figure 9.3.

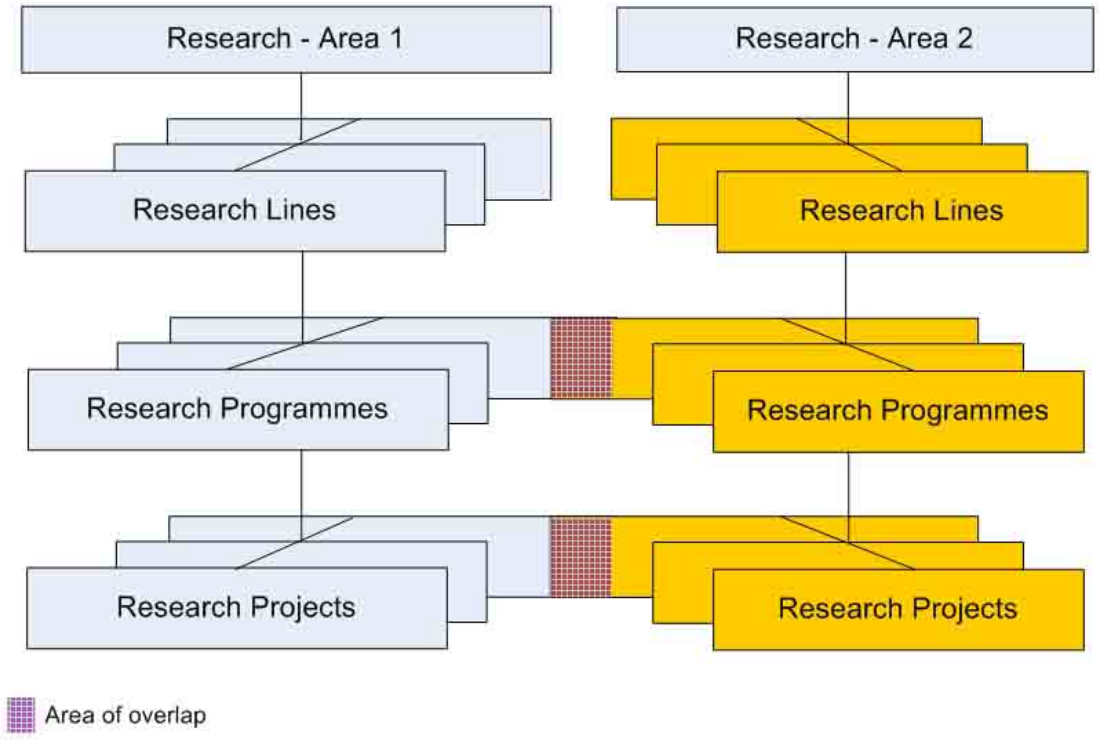


Figure 9-3: Organisation of Research Programmes

Within Research Area 1 on the left are defined several lines of research. Each line of research consists of several research programmes, and each research programme consists of several research projects. Similarly, Research Area 2 on the right also consists of research lines, research programmes and research projects.

Because some research issues are multi-sectoral by nature, it is possible that overlapping research programmes or projects will be identified within different research areas, as is depicted in Figure 9.3 as an "Area of overlap". For example, "vaccines" may be identified as a research programme within both Health research and Agricultural research. It is the responsibility of MCT, based on the annual research plans that are submitted to it by each research area, to identify possible overlaps in programmes and projects, and to facilitate the resolution of such overlaps, so that resources are used optimally and collaboration is enhanced.

The consolidation of all the research plans from the different research areas, including research lines, programmes and projects, will constitute a national research agenda, and will articulate plans for R&D that should be aligned with national priorities.

8.4 Regional Centres for Science and Technology

The function of the Regional Centres for Science and Technology (CRCTs) in extending the reach of MCT into the regions is fundamental to the success of the MOSTIS. The main objectives of the CRCTs are to coordinate, develop and promote applied and targeted research, innovation and dissemination of science and technology for development. CRCT are empowered to:

- Evaluate socio-economical potential of technological innovations and identify the kind of support needed so that the potential may be realised;
- Carry out, coordinate and monitor scientific research and innovation, and support appropriate technology transfer for the main socio-economic activities in their region;
- Promote and support scientific activities, technological development and innovation, and the popularisation of S&T;
- Carry out capacity building activities for workers, technicians and graduates in general, in terms of new technologies, literacy and technology adoption;
- Promote the establishment of experimental research laboratories with a local focus;
- Promote the publication of appropriate S&T, together with the central functions of MCT, by organizing exhibitions, fairs, bazaars and other programmes;
- Evaluate the efficacy development activities and make recommendations as to their enhancement;
- Mobilise scientific and private sector partners, civil society, NGOs and international institutions, in order to support the CRCT's activities.

With the establishment of the three CRCTs, MCT will have the means of implementing programmes and projects all over the country, and will also have an effective presence close to the main beneficiaries. Each CRCT consists of a head office that covers a region of Mozambique made up of several provinces. The three head offices are located in areas which are considered to have the potential to be centres of economic and productive activity in the

region, namely in Nampula, Tete and Gaza provinces, for the northern, central and southern zones respectively.

For each province in the region there is a Provincial Nucleus of Science and Technology (NPCT), and within the districts in a province there exists a District Nucleus of Science and Technology (NDCT) where this is justified. Each NPCT and NDCT includes several professionals from a wide range of disciplines, one of whom acts as the coordinator for the Nucleus. The team forms a virtual structure, and as individuals and together they act as an extension of MCT in the province or district. Therefore, all contact with MCT by institutions and organisations should in the first instance be made through the nearest NPCT or NDCT.

8.5 The Thematic Scientific Councils

The Thematic Scientific Councils play an important role in developing science and technology policy, and in implementation, acting as catalysts and coordinators. They are viewed as important and necessary mechanisms for the growth, development and sustainability of the S&T system. They serve as vehicles for enhancing the efficacy of the organisation of research in Mozambique, and in particular improving the definition of and coordination between research areas, lines, programmes and projects. Therefore, MCT is creating Thematic Scientific Councils in the strategic areas, with the aim of to strengthening implementation of the agendas for poverty reduction for each strategic area.

The objectives of the Councils include:

- Identification of the key research areas for the development of Mozambique;
- Identification of the short, medium and long term strategic objectives for each key area, so that the sustainable development objectives are attained for the reduction of poverty and economic growth;
- Promotion of high quality scientific research in the areas of strategic development, according to the identified strategic objectives and ethical, social and environmental principles;
- Advising the government concerning its sectoral interventions, based on the research results, and on the principles of independence, competence and professionalism of the members of the Councils.

The Councils will be composed of stakeholders with solid professional track records, from academia, government, civil society and the private sector.

8.6 Technology Transfer

There is a wide variety of well established and emerging technological solutions available throughout the world, both in the form of proprietary products, and as freely available global public goods. However, Mozambique currently has little capacity to identify, adopt, absorb and adapt those technological solutions that match particular needs, both nationally and at a local level. Hence, dependence not only on imported technology, but also on the related imported expertise is high. In order to break out of this spiral of dependence, mechanisms are needed to allow Mozambique to benefit from the most appropriate innovations and technologies created elsewhere in the world. Effective technology transfer should include the following activities:

- Search locally, nationally and globally for technology relevant to specific needs;
- Test whether such technology works and can be used by the anticipated beneficiaries in the relevant circumstances in Mozambique;
- Adapt (contextualize and customise) the technology as much as is required for use in Mozambique;
- Develop the local capacity and capability to install, maintain and support all aspects of the technology (not only the parts that have been adapted for local use). This is a crucial step, both for the absorption of the technology, and for breaking the cycle of dependence;
- Once successfully in use in Mozambique, if it is clear that the technology is strategic (i.e. it has a long life and a wide and growing potential market), the possibility of local production and further development of the technology (or sub-components) should be considered.

One specific area where technology transfer can have great impact is in enabling those involved in some economic activity to enhance the value of their product or service. Too often, products are sold in a relatively raw condition, which does not command a high price. By processing the product in some way using an appropriate technology, significant value can be added to the product, thus increasing the revenue from the product. Specific

programmes must be implemented to move producers, particularly small-scale producers, up the value chain.

The transfer of technology to poor communities to enable them to solve problems often requires local adaptation. Sometimes additional development is also needed to prepare a technology to be transferred because it is not suitable for the environment or has to conform to different standards. In both cases there can be opportunities for significant innovation. Community Technology Centres should be established in the regions to lead and promote the transfer of technologies.

Technology transfer should be promoted through the establishment of tax free zones, to enable access to new technologies by Mozambican society, and to enhance the role of technology in development.

8.7 The Roles of the Public and Private Sectors

While the total R&D investment in a country is an important indicator of the effectiveness of the S&T system, another important indicator is the proportion of R&D that is privately funded versus being publicly funded. In successful industrialised countries the public sector funds up to some 40%, and the private sector above 60%, of the total R&D investment. Therefore Mozambique should implement ways of encouraging an increase in private sector investment in R&D by, for example, providing tax incentives to the private sector to invest in R&D, and through providing matching funds under carefully designed conditions.

Public-private partnerships, consisting of collaborative programmes or projects that are jointly supported by both sectors, should be encouraged. In developed countries the public institutions, such as universities and research institutes, receive a significant part (up to more than half) of their research investments from joint projects partly funded by industry and other private sources. In addition, the public funding agencies will often encourage collaboration between industry and universities or research institutes through specially-designed funding mechanisms such as grants and high-risk loans to the parties.

Partnering between public and private institutions can greatly enhance the economic and social benefit of university research. Applied research projects need to have industrial partners that can benefit from the research results. The universities benefit not only from increased funding but also from more focused projects with clearly defined goals, budgets

and schedules. The students benefit by getting acquainted with the requirements of industry, and their involvement in such projects offers them good recruitment channels for employment at the participating companies. There are also advantages for the private sector. Small and medium size enterprises that cannot afford to have research personnel and facilities of their own have a means of access to R&D facilities, allowing them to remain competitive. Through publicly-funded incentives, large companies are encouraged to undertake R&D that without such funding would be viewed as being too risky. For the private sector as a whole, partnering with universities and public research institutes provides access to the latest technologies, to knowledge pools and to qualified personnel for recruitment. Therefore, measures should be introduced to stimulate the private sector to undertake research in partnership with the academic institutions.

While partnerships with universities can make research facilities available to SMEs, this alone is insufficient. MCT should stimulate and support the creation of additional S&T and R&D facilities on a regional basis, and for priority sectors, that are accessible by SMEs. Such facilities need to include both R&D infrastructure and expert staff.

8.8 Business Clusters, Science Parks and Incubators

The probability of an isolated company succeeding in the rapidly globalising world economy is small. Today, even the largest companies form alliances and networks all over the world, even with their competitors. This observation lies behind the emergence of competitive clusters of companies as a model for business success. Clusters may consist of a set of companies located in a contiguous and restricted geographic area, with complementary specialisations, focused on a limited set of market niches. Alternatively, they may be made up of several, geographically dispersed, concentrations of companies, all operating within an industry (such as the aircraft construction industry in Europe). Each concentration would be a producer of specialised components (such as aircraft engines), which are made up into products for the target industry.

Clusters can also be classified according to their goals. A *local cluster* operates within a defined geographic area, within a sector such as education, health care or construction, while a *trading cluster* has commercial links outside the defined geographic area, and usually has a focus on exports. The formation of local clusters can assist in critically important ways

the emergence and growth of small and medium enterprises (SMEs). For countries with small internal markets the trading cluster model is particularly important. By addressing more widespread markets the benefits of scale may be realised. Thus trading clusters typically enable increased productivity, lower costs, much larger patent portfolios and the capacity to pay higher wages. Trading clusters serve as economic engines for their regions. The challenge for policy lies in having friendly regulatory environments, and in creating mechanisms to rapidly identify and appropriately respond to emerging sectors in which trading clusters would flourish, thereby bringing wider economic benefit.

Science parks and incubators today play an essential role for the introduction of new products and services in an innovation system. They facilitate the creation and growth of new, R&D-based companies and provide platforms for interaction between universities and companies. They offer facilities and services and have often become the most desired locations for successful companies.

8.9 Knowledge and Intellectual Property Rights

The property right is composed by two components, which are the author's copyright and industrial property. This is divided into patents, brands, and models of utility and denomination of origin. The author's copyrights, patents and industrial drawings fundamentally express the findings of the science. The latter mechanisms constitute intangible values, which have nowadays an increasing importance for trade. Poor countries need to maximize not only the components of author's copyright and patents, but also denomination of origin and brands.

Technology transfer and licensing of Intellectual Property Rights (IPR) derived from scientific and technological research results are matters of particularly importance for small countries and companies. Because of their small size they very often cannot develop for themselves the technologies that they need, and so they remain largely dependent on inward technology transfer. On the other hand, research institutes in developing countries that make discoveries with economic potential typically do not find partners in their own countries.

In the context of the Knowledge Economy and rapid advances in technology, especially digital technologies, complex issues arise concerning IPR. For Mozambique it is

particularly important to protect IPR, for example, when establishing outside partnerships and for commercialisation rights.

Mozambique needs to have the capability to address these issues. Mozambique is a member state of the World Intellectual Property Organisation, which is concerned with issues associated with patents, trademarks and copyright. It is important to consolidate the legal and regulatory framework in the area of IPR, as well as to establish the technical skills and capacity to address issues related to IPR protection on behalf of the concerned parties, in the country and abroad.

8.10 S&T Ethics Policy

There is thus need to formulate a policy on ethics for science and technology which defines the general principles, criteria and rules of conduct that must be upheld by all science and technology practitioners when engaged in scientific and technological activities. Mechanisms should also be established for promoting and applying the policy, and for detecting and dealing with any infringements.

The S&T ethics policy should be based on fundamental human rights and other relevant international principles, and it should seek to ensure that the interests of all Mozambicans are served, at individual, community and national levels. The policy should be applicable to all S&T practitioners, both national and foreign, and it should include at least the following basic principles:

- Science and technology should be used as instruments for serving the well-being of all people, and for peaceful purposes;
- Science and technology should be used in the service of democracy and social justice;
- Access to the benefits of science and technology should be equitable. Science and technology should be used for the development of Mozambique (for poverty reduction and wealth creation);
- Scientific research performed in Mozambique that is funded by international agencies should be undertaken with the knowledge and participation of Mozambique's scientific community, and the benefits should be made available to Mozambicans;
- The practice of science and technology should not infringe upon anyone's human rights, in particular their integrity, freedom and dignity:

- Science and technology should be practiced with full respect for human life, health, privacy and dignity, and in compliance with the World Medical Association Declaration of Helsinki;
- Science and technology should be practiced with due regard to both the principle of intellectual freedom and of social responsibility;
- Science and technology practitioners should maintain a high commitment to the principles of honesty and transparency concerning the work of their colleagues, the public's right to have access to knowledge, and the integrity and validity of the scientific data.

8.11 Strategic Issues for the National S&T System

Mozambique has several components of a fully developed national S&T system. However, these components themselves require strengthening, while missing components should be identified and established. It should also be understood that some components may have a lower priority at this stage of the lifecycle of the system, but that as it develops and matures, the priority may need to be raised.

While the S&T system includes both public and private components, all of which are essential to the effective performance of the system as a whole, the conditions under which public and private components function are different in some respects, and MCT should make allowances for this in its approach. The major portion of MCT's resources and efforts should be targeted at the public sector components, building up their capabilities and capacities and using them as implementing agencies for the strategy. In doing so, MCT should establish an environment for the private sector components that encourages them to play their role and become aligned with the strategy.

In order to strengthen the S&T system and to promote innovation within Mozambique, a high-level Science, Technology and Innovation Council should be established comprised of leaders from industry, academia and civil society, to advise the Government on all matters related to innovation and the S&T system. The Council should be served by a permanent secretariat that would manage the operational aspects of the Council's affairs, including research and policy studies. In addition, a national Science and Technology

Academy should be established to stimulate research and the dissemination of research results.

It is important that the visions, missions, policies and strategies of the research institutes be aligned with national priorities, particularly as expressed by the MOSTIS. It is necessary to restructure the system of research institutes, to improve alignment and collaboration, to enhance performance and to address deficiencies. Any such restructuring should be done only after proper consideration, and with much care. MCT should initiate a process of review of the system of research institutes to assess the nature of restructuring and realignment necessary.

As the Ministry of Education and Culture is involved in research through the HEIs, it is important that there be a robust communication and coordination mechanism, at both strategic and operational levels, between this Ministry and MCT.

An efficient and effective R&D system requires good communication channels so that those within the research community, taken as a whole, as well as members of more specialised groups, may share information amongst themselves quickly and easily. A sound and effective communications infrastructure is therefore necessary. Furthermore, for the results of R&D to be allowed to have the highest and widest impact, researchers should be encouraged to share their research findings using methods that enable effective communication with all segments of society. In particular, mechanisms should be established to promote the diffusion of scientific knowledge that is developed in the universities into industry, so that such knowledge can have a greater impact on the economy.

8.12 Performance Indicators

Studies have been undertaken internationally to analyse how the level of R&D investment relates to growth in GDP, and clear correlations may be identified, but the studies also indicate that there are complex relationships between several variables.

One measure of the performance of the S&T system can be had by looking at the input to the system (i.e. the level of funding) and the results obtained. The scientific and technological output or results may be measured by indices such as the number articles published in peer-reviewed journals, numbers of citations and number of patents registered. However, these indices do not measure economic and social benefits such as competitiveness

of the national economy and industries, economic growth, structural evolution and diversification of the economy, improvements in quality of life and environment, and harmonious development of the society. While it is expected that R&D outputs will be correlated with R&D inputs, when making comparisons between countries large differences are evident due to wide variations in the efficiency of each national system of innovation in converting the inputs into socio-economic benefits.

It is all too easy to focus the measurement system on indicators that are straightforward to measure, but which do not reflect the essence of the desired result. The actions and behaviour of individuals are influenced by how they are measured and rewarded, not by the policy guidelines and strategies themselves. The measurement and reward systems should therefore be evaluated regularly to assess whether the desired policy results are being achieved.

In summary, in order to review the performance of the S&T system, an evaluation system using the best available indicators will need to be implemented. This will enable a performance baseline of the S&T system to be established, and will also allow the benchmarking of its performance against S&T systems world-wide, which will in turn make possible improved policymaking, and also the design of incentives to further enhance performance.

9 Funding the S&T System

9.1 Funding Organisations and Instruments

Funding organisations and instruments have a very important task in integrating the S&T system, and in ensuring that activities are appropriately focused. A key source of funding for S&T in Mozambique is through international funding partners, agencies and instruments. Such funding is essential if S&T is to be used effectively in reducing poverty and enabling the creation of wealth. The funds for many of the funding instruments that need to be established in Mozambique will be sourced from such funding organisations. Public-private partnerships can be enhanced by appropriate funding instruments. The institutional funding that covers the basic costs of universities and research institutes needs to be complemented by competitive funding.

Institutional public funding from the government budget, channelled through ministries, forms the basis of university and research institute funding. The trend in using these funds is towards higher autonomy of the institutions. They operate under general policy guidelines and have specific goals to achieve, but have an increasing budget authority in order to best meet their goals. Institutional funding ensures the continued life of institutions, and that various fields of endeavour have baseline funding.

Competitive funding involves open competition by research teams for funds allocated to targeted research domains. The allocation is normally based on policy objectives, but these need to be sufficiently broad. Competitive funding has many advantages when compared to institutional funding. First, it rewards individual initiative by allowing successful and entrepreneurial researchers to receive much larger resources than they would from institutional funding. Second, it is much easier to reorient funding than institutions. Thus research in new fields that have a high priority within the national research agenda can be initiated and pursued more quickly. Third, competitive funding is well-suited for promoting multidisciplinary teams and university-industry partnerships. And fourth, since all international funding is competed for, to a greater or lesser degree, there is significant value in Mozambican researchers gaining experience in competing for funding. Competitive funding is best managed by independent funding agencies which are more easily able to craft flexible funding instruments, and to attract suitably qualified professionals.

Funding instruments have to be tailored to project and programme objectives. Universities and research institutes need grants without payback requirements. In some cases they may receive royalty revenues from technology licensing or become equity owners in research-based companies, although such arrangements must be entered into with caution. In other cases, revenues may be gained from performing contracted research. Small and medium size companies need access to a combination of grants and loans, the latter to be repaid from successful projects. Large companies may need access to loans.

Venture capital plays an important role in financing innovation, especially for financing the high-risk phases of the innovation chain. Typically, new products have high development costs, with a narrow time window to get to market, especially if an international market is in view. A small company involved in new product development will usually have

capital requirements that exceed what can be met through self-financed growth. However, it is often at the pre-commercialisation stage that the most acute need for funding is experienced, i.e. after the preliminary research is completed, but before the venture capitalists are prepared to become involved. It is this gap that prevents many innovators and entrepreneurs from succeeding. Appropriate funding mechanisms should be identified and established, such as angel investors.

9.2 Funding and Coordination

An immediate challenge for funding lies in setting up appropriate mechanisms for disbursing S&T funds in a way that enhances the overall performance of the S&T system. To ensure the efficient use of S&T funds, to avoid duplication as far as possible, and to promote synergies where these may exist, a means is required for coordinating the research efforts being undertaken in Mozambique. MCT will play a lead role in this coordination. Research plans will be submitted to MCT by each research institution on an annual basis, for harmonisation. This will enable MCT to identify duplication, and also opportunities to exploit synergies. A National S&T Coordination meeting will also be held on an annual basis (or more frequently if necessary) that will bring together all relevant stakeholders, including MCT, CRCT and the research institutions. The meeting will be a forum at which research priorities and plans may be discussed, adjusted and approved, to ensure harmonisation and an optimal approach.

To promote the effective use of S&T funds for R&D it is important to encourage improvements in the capabilities and capacities, and the research management processes and performance of the institutions that will be funded to undertake R&D. In this regard, MCT should establish an institutional grading system for institutions being funded. An institution's assessment within this system will be used in determining the level of funding provided to the institution and to programmes and projects undertaken by the institution through instruments such as the National Research Fund.

The Government should commit to achieving an S&T expenditure level within Mozambique of 0.8% of GDP by the year 2010.

In order to keep international financing agencies fully appraised concerning the use of funds for S&T, and to promote accountability on behalf of the research institutions and other S&T institutions involved in managing the funds, a meeting of all these parties will be

arranged on an annual basis to assess the results of the previous year, and to consider the plans for the following year.

Research and related activities will be funded through a National Research Fund (see below) and through funds allocated to a particular sector. The latter funds will be provided by a funding agency to the relevant research institutions in the sector on the basis of the research plans that they have submitted.

9.3 National Research Fund

A National Research Fund (NRF) has been established and key mechanism for providing funding streams for S&T are currently being developed. The NRF is a national, independent institution, established by and operating under a mandate provided by the Minister of Science and Technology. It will invite proposals for funding, evaluate them, award funding, and monitor and evaluate the results of the funded proposals, as well as fund on its own initiative programmes and projects that promote and enhance S&T in the country. The fund will make use of several funding instruments, with each instrument being designed to achieve a specific purpose. Examples of such instruments include:

Funding Instrument
1. **Research projects, on a competitive basis.** Researchers will be invited to submit research proposals for funding. These will be adjudicated and funding will be awarded on a competitive basis, using published criteria.
2. **Institutional development.** In order to enhance Mozambique's research capacity, some funds will be available for use for additions and improvements to the research infrastructure of research institutions. These funds will also be made available on the basis of successful proposals.
3. **Government-commissioned research projects.** It must be anticipated that from time to time the Government will identify specific research projects that need urgent attention to address national priorities. This funding instrument will be used to fund such projects.

Funding Instrument
4. **Innovation and technology transfer.** A portion of the NRF's resources will be allocated for funding the high-risk phases of the innovation and commercialisation of new products and services, as well as for the transfer of technology. Funding will be awarded on the basis of successful proposals.
5. **S&T development.** This fund will be used to assist in creating a culture of S&T, to build awareness, to enhance S&T capabilities and capacities, and for related initiatives. Both solicited and unsolicited proposals for funding will be considered.

Funds will be allocated by MCT specifically for each funding instrument on an annual basis. Funds designated for one funding instrument may not be awarded to a recipient through another instrument without the prior approval of the Minister of Science and Technology.

10 Strategic Objectives and Programmes

The overarching vision of the MOSTIS is that science, technology and innovation have the potential of significant benefits across all segments of society in both the short and long term, for the public and private sectors, and also for rural and impoverished communities. In other words, STI is essential for poverty reduction and economic growth in Mozambique. With this in view the following strategic objectives have been formulated, for a ten-year time horizon. The programmes may be of short, medium or long term as indicated, corresponding to three, six and ten year timeframes.

Objectives for 2015	***Strategic Objective 1*** ***Foster a culture of innovation throughout Mozambican society***
Results expected up until 2015	• Popularising science and technology throughout Mozambican society, enabling Mozambicans to feel confident in participating in the knowledge and technology-oriented global society; • Promoting an entrepreneurial outlook and innovative orientation throughout the S&T system; • Bringing awareness of science and technology and the role of innovation.
LONG TERM Programmes	• Create awareness amongst the top leadership of the strategic role that S&T can play for the development of the country, and of the high-level issues concerning S&T for development; • Stimulate the development, codification, and diffusion of locally-generated knowledge (for example through the CRCTs); • Develop innovative ways of using technology in communicating and sharing information with illiterate communities (for example voice, video, animation); • Identify the innovators in society that have inventions and create mechanisms for them to turn their inventions into products.
MEDIUM TERM Programmes	• Enhance the science festival, currently held annually in Maputo, and extend it to other parts of Mozambique; • Create and nurture professional associations and institutions that will promote the use of S&T at all levels in the country.
SHORT TERM Programmes	• Establish mechanisms for the diffusion and dissemination of S&T information; • Establish mobile S&T demonstration programmes.

Objectives for 2015	***Strategic Objective 2*** ***Promote grass-roots innovation and the use of S&T-based approaches by poor and disadvantaged communities***
Results expected up until 2015	• Finding creative ways of encouraging the use of the scientific approach to solution building by poor and disadvantaged communities; • Establishing high-impact approaches and tools using ICTs to communicate and share information with illiterate communities, giving priority to the most vulnerable social groups.
LONG TERM Programmes	• Undertake a research programme in the social sciences to determine optimal ways of promoting grass-roots innovation amongst impoverished communities.
MEDIUM TERM Programmes	• Encourage the use of the scientific approach to solution building in impoverished communities through ICT, and in particular, through interactive multimedia-based learning tools; • Create and deploy ICT applications to address specific development issues, such as learning tools for construction of water depots, small-scale dams, sanitation facilities, and the production of seeds of improved varieties; • Implementation of pilot projects amongst impoverished communities with the aim of stimulating wealth-creation initiatives.
SHORT TERM Programmes	• Establish the three Regional Centres for Science and Technology (CRCTs); • Encourage collaborative approaches to addressing community problems using S&T amongst impoverished communities.

Objectives for 2015	***Strategic Objective 3*** ***Promote R&D and innovation within the public and private sectors***
Results expected up until 2015	• Promoting partnerships between the public and private sectors to encourage innovation and the transfer of technology for product commercialisation; • Establishing facilities that will encourage the incubation of higher-risk, higher-gain start-up SMEs; • Stimulating excellence in multidisciplinary and collaborative research and innovation by individuals and institutions; • Building a capability to manage and safeguard intellectual property rights; • Strengthening SMEs and competitiveness.
LONG TERM Programmes	• Establish incentives for public-private partnerships for innovation; • Develop a national biotechnology strategy for Mozambique; • Develop a national ethno-botany strategy for Mozambique; • Establish a networked centre of excellence for biotechnology; • Establish an information base for ethno-botanical knowledge (native species); • Promote science parks, and local and trading clusters.
MEDIUM TERM Programmes	• Establish a networked centre of excellence for ethno-botany; • Establish regional S&T facilities with R&D infrastructure and expertise that can be used by SMEs on a shared basis, thus enabling SMEs to engage in R&D without the need for their own in-house infrastructure; • Raise the level of awareness amongst researchers of the importance of environmental sustainability.
SHORT TERM Programmes	• Introduce measures to stimulate the private sector to undertake research in partnership with the academic institutions.

Objectives for 2015	***Strategic Objective 4*** ***Promote the transfer of technology***
Results expected up until 2015	<<**Missing**>>[PHG1]
MEDIUM TERM Programmes	• Establish the capability for technology transfer in the CRCTs; • Establish Community Technology Centres to promote technology transfer; • Stimulate the development of the capability to adapt and absorb imported technologies, especially on the part of new companies.
SHORT TERM Programmes	• Establish mechanisms for small-scale producers to provide inputs to research in order to enable the enhancement of value-addition to products and services; • Establish mechanisms to subsidise training, research and development for new and small companies; • Establish mechanisms to facilitate the transfer of new scientific knowledge from the universities to industry; • Establish a regulatory framework that encourages effective technology transfer; • Disseminate and promote information relevant to technology transfer to SMEs, including information concerning available technologies and services; • Identify and pilot high-impact, technology transfer initiatives.

Objectives for 2015	***Strategic Objective 5:*** ***Promote the use of ICT for good governance and service delivery, and for the diffusion of knowledge, in support of poverty reduction and economic growth***
Results expected up until 2015	• Remove physical distances and enhance real-time exchange of knowledge; • Promote networking of institutions, individuals and geographic regions; • Promote collaboration and sharing of knowledge between stakeholders; • Promote a new channel for service delivery; • Promote economies of scale and replication of developed solutions; • Promote transparency and openness; • Promote open and multi-directional communication.
MEDIUM TERM Programmes	• Establish information technology standards, national platforms and management mechanisms; • Identify business models to enable lower-cost connectivity for citizens, Internet Access Centres, the private sector and government; • Establish and scale up community access centres.
SHORT TERM Programmes	• Stimulate research programmes at academic institutions to study low-cost access solutions (wireless technologies, low-cost computers, etc.); • Use of ICTs to mitigate the impact of HIV/AIDS and reduce the vulnerability of the rural population; • Establish a national programme for ICT skills development, having a special focus on youth, trainers and ICT professionals; • Develop a range of multimedia-based learning material focused on ICT knowledge and skills, for use by youth and by impoverished communities; • Establish an S&T knowledge and communication portal; • Establish a government data centre; • Establish a FOSS Centre of Excellence within an appropriate institution.

Objectives for 2015	***Strategic Objective 6:*** ***Promote human resource development at all levels in the areas of science, technology and innovation***
Results expected up until 2015	• Promote the education of youth in the fields of science, engineering, technology and ICT; • Increase the number graduates earning advanced degrees in S&T; • Stimulate the education of women in the fields of science, engineering, technology and ICT; • Reach a significant share of the economically active population with introductory and advanced S&T education and training; • Foster the interaction and collaboration of Mozambican researchers with their regional and international counterparts.
MEDIUM TERM Programmes	• Create S&T centres of excellence at selected universities; • Upgrade the S&T capability and infrastructure in the K-12 education and vocational training systems; • Stimulate the development and deployment of informal S&T learning programmes using interactive, multimedia-based learning tools; • Carry out capacity-building activities and train teachers in the basic sciences at all levels, through the CRCTs; • Set up extramural classes in the basic sciences for secondary students showing talent in the sciences, through the CRCTs.
SHORT TERM Programmes	• Establish S&T scholarship programmes for MSc and PhD students; • Establish research-oriented, postdoctoral and sabbatical scholarship programmes; • Establish new post-graduate S&T degree programmes in line with national priorities; • Improve the science laboratories in HEIs; • Establish collaborative relationships with regional and international educational and research institutions; • Establish a programme to enable academic researchers to gain experience from an industrial environment; • Promote the popularisation of science amongst secondary school students, and identify and encourage those who show particular S&T talent; • Establish mechanisms to promote S&T education and training of employees throughout their careers; • Develop mechanisms to fast-track women into and within the S&T system through, for example, targeting women's leadership organisations. This programme should be coordinated and led by women; • Promote the scientific education and training of women through targeted scholarship programmes; • Follow up and monitor the design of career paths for research institutions, and the integration of researchers in research careers.

Objectives for 2015	***Strategic Objective 7*** ***Build and improve the policy instruments, institutions and infrastructure of the S&T system***
Results expected up until 2015	• Addition of capabilities, capacities and infrastructure; • Review and possible restructuring of the components of the system of S&T; • Greater alignment of the outputs of the system with national development priorities; • Making the system more effective and efficient in pursuing the goal of poverty eradication, while also fostering socioeconomic development.
MEDIUM TERM Programmes	• Establish a technology Foresight capability for Mozambique; • Build the capability to respond to natural disasters and crises; • Stimulate and support the creation of additional S&T and R&D facilities on a regional basis, and for priority sectors, that are accessible by SMEs; • Enhance the performance of the S&T system by adding new capabilities and processes.
SHORT TERM Programmes	• Review the functionality and performance of the national S&T system as a whole, to identify missing components, and components that need to be strengthened; • Reorganise the current S&T institutions to improve the efficacy and efficiency of the national S&T system; • Improve the ICT infrastructure of the S&T system by building a high-speed R&D network; • Build a knowledge sharing system suitable for S&T-based knowledge; • Draw up a national research agenda; • Encourage the components of the S&T system to become learning organisations; • Establish a Science and Technology Academy; • Run a technology Foresight programme for Mozambique; • Review the existing research institutes, and assess the need and feasibility for the creation of new research institutes; • Develop and disseminate a policy for Intellectual Property Rights; • Develop a policy for S&T ethics; • Establish suitable mechanisms for applying the S&T ethics policy, and for ensuring the promotion of sound ethics within the S&T system.

Objectives for 2015	***Strategic Objective 8*** ***Establish funding policies and mechanisms for research and innovation***
Results expected up until 2015	• Capacity to deploy funding for implementation of the programmes identified in line with the strategic objectives; • An efficient and effective STI funding system set in place.
MEDIUM TERM Programmes	• Determine and establish the most efficient and effective mechanisms and channels within the Government for the funding of S&T; • Establish funding partnerships with international funding sources; • Increase the participation of the private sector in funding STI.
SHORT TERM Programmes	• Establish policies and criteria for the National Research Fund; • Establish a National S&T Coordination meeting consisting of MCT, CRCT, the research institutions, and other S&T stakeholders; • Establish a grading system for research institutions; • Establish systems and forums that will engender confidence on the part of international funding partners in Mozambique's S&T system; • Develop systems for follow up, monitoring and evaluation of the financial performance of programmes and projects.

Objectives for 2015	***Strategic Objective 9*** ***Review, evaluate and enhance the performance of the S&T system***
Results expected up until 2015	• Efficient capacity for continuous monitoring, and development of expertise for improvement of the performance of S&T; • An integrated S&T indicator system enabling the evaluation of its impact on economic development and poverty reduction.
MEDIUM TERM Programmes	• Assess the performance of the S&T system at regular intervals on an ongoing basis.
SHORT TERM Programmes	• Establish a benchmarking baseline of performance for the institutions in the national S&T system; • Develop a set of indicators for measuring outcomes and impacts on poverty reduction that may be attributed to S&T activities; • Develop expertise in the MCT in areas such as leadership, human resources management, planning, and high-level project management, through running training courses.

Objectives for 2015	***Strategic Objective 10*** ***Promote the mainstreaming of S&T within all sectors***
Results expected up until 2015	• An S&T system well established in all sectors and in society.
SHORT TERM Programmes	• Stimulate a national debate on the crosscutting role of S&T and the need for holistic solutions; • Encourage all government ministries to appreciate the fundamental and holistic role of STI within their own mandates; • Establish frameworks and mechanisms to ensure coordination of S&T activities across all ministries.

11. Implementation

By drafting this strategy for STI, the ground has been laid for Mozambique to have a framework and guide for all those institutions and individuals who participate in the S&T system. The strategy sets the direction, and therefore can be referred to as a guide for S&T activities. However, without a solid approach to implementation, the MOSTIS will not achieve its strategic objectives. At the same time, it must be recognised that implementing the MOSTIS will be a complex task because of the range of different players involved, including the public and private sectors, research institutions, HEIs, civil society, and the citizens of Mozambique. It will require commitment and participation by all the stakeholders in the process of developing the country. It is also important to define the roles of the different players so that they work together in a coherent way, and so that their annual plans mirror substantially the approved strategic programmes, in order to progress towards the vision of STI for Mozambique.

The time horizon for implementation of this strategy is ten years. For proper evaluation of outputs, the envisaged programmes have been classified as being of short, medium or long term duration, corresponding to three, six and ten years, respectively. The strategy has a dynamic character and will be subject to review every three years, for which stakeholders in different sectors and in society should play an active role. In some cases there will be programmes in their initial stages and, due to their educational nature or complexity, their impact can be evaluated only on a long term basis. Institutional support activities precede expansion activities and are therefore planned for the short term, i.e., for completion by 2009. Other initiatives are permanent by nature, despite the possibility of short and medium term assessments (such as popularisation of science and development of human resources).

The design of the strategy was contributed to by all sectors of society involved in issues of science, technology and innovation. A particular contribution was from the ministries responsible for the strategic areas, and enabled the establishment of a platform for the coherent definition of a national research agenda.

In general, MCT will play the role of regulation, coordination and management in the implementation of the strategy to ensure that the objectives of the MOSTIS are realised. In this respect, strong linkages should be created between the research institutes and other

public research institutions, to enable MCT to play this leading role. In general, line ministries are responsible for the implementation and roll-out of all programmes.

The MOSTIS document by itself is not a finished product. There is a range of instruments that need to be put in place in order to implement the broad scope of the strategy. MCT will in the short term pay attention to a number of implementation issues, with a view to executing on the strategy. These include:

- Establishing the necessary funds and funding mechanisms;
- Recruiting human resources with the needed expertise;
- Developing additional human resources;
- Putting the required infrastructure in place;
- Prioritising the identified interventions and programmes;
- Prioritising the research lines, and identifying their constituent programmes and projects;
- Planning, resourcing and executing the prioritised programmes;
- Implementing, monitoring and evaluation systems for the programmes.

11 Appendices

Appendix 1: Glossary

Applied Research

Applied research, which is also termed adaptive research, is a form of scientific research that uses knowledge from basic research and applies or adapts it to a new environment or system, whether using existing techniques or through the development of new techniques. Applied research seeks practical solutions to specific problems.

Basic Research

Basic research is a form of scientific research with the primary aim of increasing humankind's stock of knowledge, with no particular focus on the usefulness or application of such knowledge.

Experimental Research

In experimental research (a form of scientific research) the researcher sets up an experiment in which key variables or parameters are controlled and changed by the researcher (e.g. temperature, length of time, amount of water). The researcher may then observe and interpret the effect of the changed variables or parameters on the results.

Innovation

One definition of innovation is that it is the process of transforming an idea, whether or not generated through R&D, into a new or improved product, process or approach that addresses the real needs of society and which involves scientific, technological, organisational, commercial or social activities. Innovation may therefore involve invention, but the emphasis lies on the tangible and on-going benefits that result from innovation, which distinguishes it therefore from mere invention.

Invention

An invention is the act, or the result, of devising something new (such as a physical item, a process, a method or services).

Research, scientific research, research and development (R&D)

Research (also termed scientific research or research and development (R&D)), comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of the physical world, humanity, culture and society, and the use of this stock of knowledge to devise new applications that benefit people.

Researcher

A researcher is someone who is following a research career, holding the required academic or professional qualifications, and who is engaged in scientific research or the management of such research.

Science

Science is knowledge or a system of knowledge covering general truths or the operation of general laws concerning the physical world and its phenomena, especially as obtained and tested through research using the scientific method.

Technology

Technology is knowledge in forms such as techniques, tools, equipment, processes and products, that may be used to construct solutions to practical problems.

Appendix 2: Public Scientific and Technology Research Institutes

Institution	Science, Technology, Innovation and Extension Units	Types of Activity
Ministry of Transport and Communication	1-Instituto Nacional de Hidrografia e Navegação (INAHINA)	Applied research, monitoring and extension
	2-Instituto Nacional de Meteorologia (INAM)	Applied research and monitoring
Ministry of Health	3-Instituto Nacional de Saúde (INS)	Basic and applied research
	4-Centro de Investigação de Saúde da Manhiça (CISM)	Basic and applied research, monitoring and extension
	5-Centro Regional de Desenvolvimento Sanitário (CRDS)	Monitoring and extension
Ministry of Agriculture (MINAG)	6-Instituto de Investigação Agrária- IIAM (experimentação florestal, investigação veterinária, produção animal e investigação agronómica)	Applied research, monitoring and extension and development programme
	7-Cenacarta-Centro Nacional de Cartografia e Teledeteção	
Ministry of Fisheries	8-Instituto de Desenvolvimento de Pesca de Pequena Escala (IDPPE)	Extension, and development programme
	9-Instituto de Investigação Pesqueira (IIP)	Applied research and monitoring
Ministry of Public Works & Housing	10-Laboratório de Engenharia de Moçambique (LEM)	Engineering and applied research
Council of Ministers	11-Instituto Nacional de Estatística (INE)	Applied research
Ministry of Education and Culture	12-Instituto de Nacional de Desenvolvimento de Educação (INDE)	Applied research
	13-Instituto de Investigação Sócio-Cultural (IISC-ARPAC)	Applied research and extension
	14 – Universidade Eduardo Mondlane (UEM)	Basic and applied research and extension
	15 – Universidade Pedagógica (UP)	Basic and applied research and extension
	16 – Instituto Superior de Relações Internacionais (ISRI)	Applied research

	Appendix 3: Agriculture: Programmes and Research Lines
LONG TERM Programmes	• Forest plantations and domestication of forest species (for wood, medicine, food and protection); • Biotechnology (characterisation and gene stock improvements, disease control and vaccine development);
MEDIUM TERM Programmes	• Establish mechanisms for the management of natural resources (water, soil, climate, pasture and fodder, flora and fauna), including: gene bank development through the collection and importation of DNA; • Inventory, characterisation and evaluation of the natural resources (vegetation, climate, including pastures, fauna, livestock, soils, and water); • Conservation of the natural resources “in and ex situ” (gene bank development through the collection and importation of DNA); • Management and planning of natural resources (water, soil, climate, pasture and fodder, flora and fauna); • Agricultural crops production (cereals, roots and tubas, horticulture and fruits); • Integrated weed and disease management; • Natural forest management; • Agro-pastural production systems; • Forest seed preservation, improvement and multiplication; • Management of animal nutrition systems (ruminants, monogastrics and poultry); • Public veterinary health (zoonoses, environment and quality control); • Animal utilisation and processing (milk, meat, hides); • Research on environmental hygiene; • Security of the quality of food and nutrition (agriculture, livestock and forest).

SHORT TERM Programmes	• Establish a national Agricultural Research Council; • Develop a policy and strategy framework for agricultural research; • Strengthen the regional agricultural research centres; • Promote technology transfer and dissemination in the farming sector; • Develop decision support systems and technologies for the management of natural resources; • Post-harvest preservation, processing and utilisation; • Utilisation of forest products; • Use of bat droppings in agriculture, including in the production of cotton.
RESEARCH LINES up until 2015	• Inventory, sustainable use, management and preservation of agricultural and natural resources (crops, livestock, soil, water, forestry, ethno-botanical resources); • Data collation and sharing systems for natural resources and biodiversity; • Characterisation of production systems and their potential impact on agro-ecological and socio-economic issues; • Inventory and preservation of genetic material of local and adapted resources; • Post-harvest preservation and processing technologies, including the link to the agro-industry; • Application of enabling technologies such as biotechnology and breeding for the improvement of production and productivity of local resources (plants, animals, forestry) and exotic species; • Development and adaptation of irrigation technologies for different production systems (small-holder and agro-industrial farming); • Food quality control and safety; • Control of diseases, vectors of diseases and pests of plants and animals, as well as zoonotic diseases;

	• Ethno-botanical studies, to harness the potential of different plant species and promote their use in health and nutrition; • Domestication and management of wildlife in captivity; • Technology transfer in various fields of agriculture.

	Appendix 4: Health: Programmes and Research Lines
LONG TERM Programmes	• Research on HIV/AIDS and on determinants of HIV/AIDS.
MEDIUM TERM Programmes	Research on: • TB and the determinants of TB; • Malaria and the determinants of malaria; • Validation of the nutritional and medicinal properties of indigenous plants.
SHORT TERM Programmes	• Establish a national advisory council on health research; • Establish a regulatory institution for health research; • Strengthen and reform the National Institute for Health; • Create mechanisms to allow formal affiliation of health researchers with the INS; • Improvement of health policies; • The impact of poor nutrition on health; • The impact of nutrient balance and alternative nutrients on health.

RESEARCH LINES up until 2015	• Research leading to the enhancement of health policies and the health system; • Diseases, and determinants of diseases, that have the largest impact on the health of the Mozambican population, such as HIV/AIDS, TB, malaria, intestinal parasites and other endemic diseases; • Nutrition-related health issues, such as ways to improve nutrition, the health impact of poor nutrition; nutrient balance; alternative nutrients; • Indigenous Knowledge Systems directed towards traditional medicine, including validation and dissemination of information concerning indigenous plants for medicinal and nutritional purposes.

	Appendix 5: Energy: Programmes and Research Lines
MEDIUM TERM Programmes	• Production of bio-fuels, including biomass gasification, bio-gas, bio-ethanol and bio-diesel; • Alternative energy sources including hydro, wind, solar and tidal wave sources.
SHORT TERM Programmes	• Production of thermal and electric energy from biomass gasification; • Production of briquettes, pellets and charcoal, including from mineral coal; • Energy-efficient methods for water decontamination; • Energy-efficient methods for lighting; • Energy-efficient methods for domestic and industrial ovens, including charcoal ovens; • Energy-efficient methods of charcoal production; • Energy-efficient methods of freezing for food preservation and preserving vaccines; • Subsidy policies; • Pricing policies; • Fiscal incentives.
RESEARCH LINES up until 2015	• The means of energy production, including bio-fuels, biomass gasification, biogas production, the production of briquettes, pellets and charcoal, and alternative energy sources, such as wind, photovoltaic and hydro, among others; • The means of efficient use of energy, related to water decontamination, lighting, domestic and industrial ovens, and food preservation; • Policies and programmes in the area of energy, including pricing, subsidies and fiscal incentives, as well as regulation on the efficiency of the technologies adopted in the production system.

	Appendix 6: Marine Sciences and Fishing: Programmes and Research Lines
MEDIUM TERM Programmes	• Strengthen and expand the existing marine sciences and fishing research capacity to create a networked national Centre of Excellence; • Monitor the fishing resources being exploited and those of significant economic or nutritional importance; • Marine and aquatic environment (oceanography, limnology), and its relation to fishing resources; • Technical testing for commercial and aquatic species production adapted to Mozambican environmental conditions; • Technologies and practices that impact the sustainability of fishing resources; • Socioeconomic and anthropological aspects of the utilisation of fishing resources, particularly in small-scale farming; • Mechanisms for restoring of habitats and for the establishment of artificial marine habitats; • Improve the knowledge of marine contaminants, in line with environment preservation and increased protection of human health; • Use of the ecosystems approach in studies, exploitation and management of fishing resources, and development of research leading to preservation of species and ecosystems; • Breeding and conservation of promising marine species by means of genetics and biotechnology; • Use and development of modelling technologies for marine ecosystems, models of fishing management, as well as for oceanography and atmosphere studies.
SHORT TERM Programmes	• Develop a coordinated, integrated national strategy for marine sciences and fishing research, covering small-scale, semi-industrial and industrial fishing; • Develop a strategy for aquaculture and create the conditions to foster an aquaculture industry; • Investigate the application of cooperative techniques to small-scale fishing, including the potential to develop incubators;

	• Environment-friendly and economic mechanisms for protection of the coast from erosion, including the stabilization of dunes and small-scale construction engineering; • Structuring and standardization of databases from research stations; • Development of geographic information systems (GIS) to backup marine exploration and the characterization of resources.
RESEARCH LINES up until 2015	• Evaluation of the fishing resources and fishing management measures (differentiating between small-scale, semi-industrial and industrial fishing); • Research on marine and aquatic environment (oceanography, limnology), and its relation to fishing resources; • Research and selection of species with better genetic potential for improved quality of germlines; • Research to address the issue of shrinking populations of species being fished; • Research on fishing technologies that ensure sustainability of the fishing resources; • Research on fishing technologies to improve handling, processing and preservation, leading to added value of fishing products; • Microbiological fishing research (main factors of contamination, and measures to conserve fish); • Maintenance of good health and productivity of the marine and coastal ecosystems; • Sustainable management of marine and coastal ecosystems; • Studies on the interaction land ocean-atmosphere, for identification of better management practises; • Marine biotechnology as means of adding value to marine-derived products; • Studies on marine pollution and its sources, and of systems to reverse the effects; • Establishment of effective and efficient surveillance of the sea and coast management; • Use of ICT in diverse aspects of marine and fishery sciences, including remote sensing technologies for surveillance.

	Appendix 7: Construction: Programmes and Research Lines
SHORT TERM Programmes	• Establish research programmes for the research lines for construction.
RESEARCH LINES up until 2015	• Research on house construction technologies and techniques, construction equipment suitable for different cultural and geographical contexts, and the adoption of related construction standards and regulations; • Research into safety matters, reformulation and adoption of construction standards and regulations based on current local construction practices and conditions; • Development of basic quality control criteria in the production and application of construction materials; • Research into reducing the production costs of construction materials, and into low-cost materials; • Research to identify the potential of locally-available construction materials, and to evaluate the socioeconomic viability of the use of such materials; • Research into construction materials that reduce energy consumption.

	Appendix 8: Water: Programmes and Research Lines
LONG TERM Programmes	• Undertake research into climatic changes and extreme phenomena such as droughts and floods, and their magnitudes and impacts; • Water and the environment, both rural and urban.
MEDIUM TERM Programmes	• Improvement of hydrographic basin management; • Research on the hydrological cycle, including surface water (quality, quantity and specific variation), and subterranean water; • Hydrological modelling, including oceanographic studies; • Research on estuary processes; • Effects of saline intrusion, and techniques and mechanisms to reduce the problem; • Pollution of estuaries and the invasion of invader species; • Water for agriculture, including irrigation systems, the improvement of the efficiency of watering and drainage systems, and into drought-resistant crops.
SHORT TERM Programmes	• Establish a framework to clarify the roles and responsibilities of, and improve communication and coordination between, the institutions operating in the water sector; • Strengthen Mozambique's participation in regional and international water research; • Dissemination of basic knowledge of water amongst all water management and utilisation institutions, including the expansion of the number of skilled people; • Systematisation, documentation and dissemination of locally-generated knowledge related to water use and management; • Recognition and documentation of the intellectual property rights related to locally-generated knowledge; • Sharing of water across the borders of the hydrographic basins;

	• Research in technologies for collecting and conserving rainwater; • Economic value of water to the country, and into techniques and methodologies for determining its economic value; • Research on water in industry, including the optimisation and improvements in the efficiency of its use, and recycling technologies; • Research on cleaning technologies and ways to minimise pollution indices; • Research into the supply of water; • Water and health, including infectious diseases and sanitation; • Research on water conservation and rationing through demand management; • Research into improving water conservation and the efficiency of water usage;
RESEARCH LINES up until 2015	• Legal and sovereignty issues related to water; • Inventory of subterranean and surface water resources, their quality, quantity and potential use; • Effective use of water resources, including rivers; • The water cycle and its management; • Purification and recycling technologies for water; • Technologies and management systems for water in the industrial, domestic and agricultural spheres; • Water conservation, including financial and political incentives.

	Appendix 9: Mineral Resources: Programmes and Research Lines
MEDIUM TERM Programmes	• Establish a scientific research institute for geology and mineral resources.
SHORT TERM Programmes	• Develop a national research plan for research for mineral resources, including research plans for the research lines that have been identified.
RESEARCH LINES up until 2015	• Local processing of mineral products and hydrocarbons in order to provide for national demand and to increase the opportunities for export; • Appropriate technology for small-scale and low-cost mining; • The use of metallic and non-metallic minerals; • The use of mineral products in construction materials; • Exploitation of hydrocarbons for energy production and other uses; • Applied geology and the environment; • Application of geophysics in the mapping of water resources and in seismology research.

	Appendix 10: Environmental Sustainability: Programmes and Research Lines
MEDIUM TERM Programmes	• Conservation of sea and coastal ecosystems; • Research on the degradation of soils, considering cause and effect of phenomena such as erosion, drought and desertification, and salination; • Research on the conservation of biological diversity, from an inclusive perspective, to prevent and control the destruction of habitats, the extinction of species, and the propagation exotic species, as well as biosecurity; • Research on the vulnerability to climatic change and adaptation to the effects of climatic change; • Research on the integrated management of the coastal area, including the search for coordination and implementation mechanisms for effective partnerships between the public and private sectors and civil society; • Research on ecosystems and wildlife species to include in preservation programmes; • Research on policies, strategies and development systems in areas of flora and wildlife conservation; • Research on suitable approaches for participation of local communities in the management of natural resources.
SHORT TERM Programmes	• Research on the alteration of the coast line (erosion and sedimentation); • Research into coastal pollution (pollution that originates from the ocean); • Prevention and control of pollution; • Research on the management of urban, hospital and industrial solid waste; • Research on the conservation of the biodiversity found in the urban perimeter; • Urban transportation including (in an integrated way) the intensity of traffic patterns, types of fuel, types and state of vehicles, and also impacts on the quality of life in terms of stress, accidents and diseases; • Organisation of integrated and participative environmental planning for a territory; • Research into the integrated management of hydro resources, keeping in mind the intrinsic value of water for humankind, for

	agriculture and industry, and for the health of the ecosystem;
RESEARCH LINES up until 2015	• Coastal Area Management; • Urban Environment Management; • Conservation of Natural Resources; • Climatic Changes; • Environment and Poverty; • Environment and Economic Impact.

	Appendix 11: Ethno-botany: Programmes and Research Lines

MEDIUM TERM Programmes	• Establish an information base for ethno-botanical knowledge.
	• Research on Ethno-botanical resources and their use in different contexts:
	  o Plants with nutritional value;
	  o Plants of medicinal value;
	  o Plants with aromatic properties for use in the production of insect repellents, hygiene and cosmetic products, and in aromatherapy;
	  o Plants for ornamental purposes.

SHORT TERM Programmes	• Establish a coordinated mechanism for ethno-botanical research and its application in economic and social development programmes.
RESEARCH LINES up until 2015	• Research into the characterisation of traditional practices, including social aspects; • Research to validate traditional knowledge; • Research into the use, production and commercialisation of products based on ethno-botanical knowledge.

	Appendix 12: Biotechnology: Programmes and Research Lines
MEDIUM TERM Programmes	• Establish a networked centre of excellence for biotechnology.
SHORT TERM Programmes	• Develop a national biotechnology strategy for Mozambique.
RESEARCH LINES up until 2015	• Adaptation and application of current knowledge and technologies generated in developing countries for improvement of the productivity of subsistence crops and livestock breeds; • Alternative technologies of land management for agriculture and livestock production; • Characterization of genetic markers of relevant traits of local food crops and animal breeds, for selection and breeding purposes; • Identification of determinants, major pathogens and vectors of high-impact diseases of humans, animals, plants and marine species; • Application of existing (and development of new) molecular detection and molecular epidemiology methods to support the control of disease; • Development and testing of new generation diagnostic assays, therapeutic and prophylactic products, derived from gene technology; • Evaluation of the diversity of Mozambique's biological resources; • Research on mechanisms of disease infection and protection in humans and animals, and mechanisms of resistance and adaptation in crops and plants that are important locally;

	• Risk analysis of biotechnology-related solutions.

	Appendix 13: Tourism: Programmes and Research Lines
MEDIUM TERM Programmes	• Research on the ecosystems and on the wildlife species to include in conservation programmes.
SHORT TERM Programmes	• Use of ICTs in the analysis of market demands of tourism products and services, and their link with the domestic, regional and international markets; • Establishment of a database of indicators for statistical purposes; • Development of indicator and evaluation systems to apply in construction of tourist endeavours; • Research on policies, strategies and the development systems in the area of conservation; • Research into better approaches for community participation in the management of natural resources for tourism purposes; • Development of monitoring and evaluation systems for hunting activities; • Mapping of tourist zones.
RESEARCH LINES up until 2015	• Establishment of a foresight system for tourism development.