

# Science, Technology & Innovation Policy Review

Mauritania



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**Review of Mauritania**



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## PREFACE

There is considerable evidence that technology and innovation have played a key role in driving economic growth and broader development in both today's developed countries and in those Asian countries that have made fast progress in economic development over the past 50 years. The sources of economic growth include not only the deployment of additional labour and capital to production through increased employment and capital accumulation, but also the introduction of improved technologies, the capabilities to use these technologies efficiently and the ability to create strong innovation capabilities among enterprises, the public sector and society more widely that promote broad based innovation. Building STI capabilities and an enabling environment for innovation, and accessing useful technologies, are therefore central to economic and social progress in all countries, including the LDCs. This is why the Government of the Islamic Republic of Mauritania requested that a STIP Review of Mauritania be prepared.

Within Mauritania, expectations of rapid socio-economic progress among the populace have risen to high levels with the anticipation that the start of oil production will create great opportunities for the country. In order to meet these expectations, Mauritania must avoid the potential trap of natural resource activities crowding out the development of other more sustainable industries through the processes that have operated to create a "resource curse" in some developing countries. In broad terms, the main challenge for the country is to manage the economy in such a way as to channel the rents obtained from natural resource activities into successful development of the broader economy. A higher level of priority on STI policies could contribute to this goal. The key question for this Review is how the country can build strong STI capabilities and an effective national system of innovation, and what benefits these can bring in terms of economic development, poverty reduction and an improved standard of living for the Mauritanian people.

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## ABBREVIATIONS

ADER	Agency for Rural Electrification
ADF	African Development Fund
AFD	French Agency for Development
AFDB	African Development Bank
ARIPO	African Regional Intellectual Property Organization
ASTI	Agricultural Science and Technology Indicators
AU	African Union
BCM	Central Bank of Mauritania
BDS	Business development services
BOP	Balance of Payments
CAS	Country Assistance Strategy (of the World Bank)
CEMAP	Mauritanian Center for Policy Analysis
CFED	Global Distance Learning Centre
CNERV	National Centre on Livestock and Veterinary Research
CNRADA	National Centre on Agricultural Research and Development
CNRE	National Centre on Water Resources
CPIA	Country Policy and Institutional Assessment
DGPIP	General Delegation for the Promotion of Private Investment
ECOWAS	Economic Community of West African States
EITI	Extractive Industries Transparency Initiative
EIU	Economist Intelligence Unit
ENA	National School of Administration
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FNARS	National Fund for Scientific Research
FNRH	National Hydrocarbon Revenue Fund
FSAP	Financial Sector Assessment Programme
FST	Faculty of Sciences and Technology
FTP	Technical and Vocational Training
GATS	General Agreement on Trade in Services
GDP	Gross Domestic Product
GER	Gross enrolment rate
GERD	Gross expenditure on R&D
GIRM	Government of the Islamic Republic of Mauritania
GNI	Gross National Income
GNP	Gross National Product
HACCP	Hazard Analysis and Control Point
HDI	Human Development Index
HIPC	Heavily Indebted Poor Countries
ICT	Information and communication technologies
IT	Information Technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IDA	International Development Agency (of the World Bank)
IDB/BAD	Islamic Development Bank
IFC	International Financial Corporation
IMF	International Monetary Fund
IMROP	Mauritanian Institute for Oceanographic Research and Fisheries
IOC	International oil company

## LIST OF ABBREVIATIONS

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IFS	International Financial Statistics
IP	Intellectual property
IPR	Intellectual Property Rights
IRDI	Industrial Research Development Institute
ISO	International Standards Organization
ITU	International Telecommunications Union
LDC	Least Developed Country
LFTP	Professional Technical and Vocational Training College
LFTPC	Commercial Professional Technical and Vocational Training College
LFTPI	Industrial Professional Technical and Vocational Training College
LNG	Liquefied Natural Gas
MDRI	Multilateral Debt Relief Initiative
MDGs	Millennium Development Goals
MEP	Ministry of Energy and Petroleum
MEN	Ministry of Education
MFI	Microfinance institution
MMI	Ministry of Mining and Industry
MPEM	Ministry of Fisheries
NEPAD	New Partnership for Africa's Development
NICT	New Information and Communication Technologies
NSI	National System of Innovation
OAPI	African Organization for Intellectual Property (Organisation Africaine de la Propriété Intellectuelle)
ODA	Official development assistance
ONS	National Statistics Office
Ouguiya	Mauritanian national currency
PMD	Mauritanian Development Gateway
PNDSE	National Programme for the Development of the Educational Sector
PRI	Public research institute
PRSP	Poverty Reduction Strategy Paper
PRGF	Poverty Reduction and Growth Facility
PRISM	Mining Sector Capacity Building Project
PRISM2	Second Mining Sector Capacity Building Project
PRSP	Poverty Reduction Strategy Paper
PSA	Production Sharing Agreement
R&D	Research and Development
RIM	Islamic Republic of Mauritania (Republique Islamique de Mauritanie)
REER	Real Effective Exchange Rate
SESRTCIC	Statistical, Economic and Social Research and Training Centre for Islamic Countries
SETN	Secretary of State for the New Technologies
SIGM	Geographical Information System
SIGE	Environmental Management Information System
SME	Small and Medium Enterprise
SMH	National Oil Company
SNDE	National Water Company
SNIM	National Industrial and Mining Company
SOE	State-owned enterprise
SOMOGAS	National Gas Company
SOMELEC	National Electricity Company
SONELEC	National Electricity and Water Company
SPS	Sanitary and phytosanitary standards
SRD	Scientific Research Department
S&T	Science and technology
STI	Science, technology and innovation

TNC	Transnational corporation
TRIMS	Agreement on Trade Related Investment Measures
TRIPS	Agreement on Trade Related Aspects of Intellectual Property Rights
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCLD	United Nations Conference on the Least Developed Countries
UNCTAD	United Nations Conference for Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
WFP	World Food Programme
WHO	World Health Organization
WIPO	World Intellectual Property Organization
UNIDO	United Nations Industrial Development Organization
WDI	World Development Indicators
WTO	World Trade Organization

## EXECUTIVE SUMMARY

This Science Technology and Innovation Policy (STIP) Review, prepared at the request of the Government of Mauritania, provides an outline and assessment of the country's current science, technology and innovation (STI)<sup>1</sup> capabilities, their STI policies and the effectiveness of their national systems of innovation (NSIs) and knowledge systems in improving the productivity of enterprises and national economic performance as well as in helping the country to address various economic, social and environmental challenges. It seeks to analyse how these have evolved in recent years, to provide an independent evaluation of whether these capabilities and the NSI need to be strengthened, how they might fit into the country's development strategy, and suggest how policymakers in Mauritania might go about doing this. It also compares the progress made in upgrading these capabilities in relation to progress made in strengthening the other main elements that contribute to promoting economic growth and development in the country.

The Review aims to (a) provide an independent and constructive assessment of STI capabilities and policies and the NSI in Mauritania; (b) evaluate the degree progress to date in improving them; (c) identify major areas of weakness; (d) evaluate the priority that should be placed on remedying them; and (e) suggest some concrete measures that could contribute to this in light of the country's specific circumstances. It also aims to raise awareness in Mauritania and beyond on the potential role of STI capabilities and effective NSI in promoting socio-economic progress in the country by addressing the various economic, social and environmental challenges that the country faces. This STIP Review is only a starting point for policy discussion within Mauritania on STI capabilities and STI policy in the country. The findings presented here, together with the various suggestions and recommendations, are also intended to serve that purpose.

The main finding of the Review is that STI capabilities, and the ability of enterprises and the public sector to effectively harness them for innovation, are currently inadequate to address the challenges that the country faces. The NSI and knowledge systems suffer from extensive systems failure. Labour productivity is generally low, and most enterprises do not have the technological innovation capabilities, and are not upgrading their production technologies, to allow them to become internationally competitive. Faster and more broadly-based human capital development is needed to strengthen the skills base, particularly in technical subjects such as science, engineering and other technical disciplines, and in entrepreneurship and management. More rapid technology diffusion and improved absorptive capacity are both needed to stimulate a stronger and more broadly based technological upgrading and improved innovation performance. Faster capital accumulation through high investment rates is needed to overcome persistently severe infrastructure bottlenecks to production, transport and trade. Faster financial sector development is needed

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<sup>1</sup> It should be noted that STI capabilities in a least developed country (LDC) context may be broadly defined to include – in addition to scientific, technological and innovative capabilities – capabilities in engineering, other technical capabilities, entrepreneurship and management and organizational capabilities. This Review takes a very broad and pragmatic approach to innovation as the introduction of new or improved products, or of new or improved processes and organizational methods in the design, production and distribution of goods and services. This includes mainly commercial introduction by firms but can also include non-commercial introduction, for example, in providing not-for-profit public services.

to improve the mobilization of domestic financial resources and their effective allocation to capable entrepreneurs with promising investment projects. Entrepreneurship skills and small and medium-sized enterprises (SMEs) need support. A neglect of STI capabilities and a lack of focus on building strong and effective NSI represent a critical weakness in Mauritania's development strategy. The Review recommends early action to remedy this through discussions on developing a realistic national STI strategy in light of national priorities and circumstances. The strategy should be integrated in its overall development strategy and policies. In the absence of this, the current development strategy may fail to deliver a dynamic economy and economic development. Intensified competition could over time strongly undermine domestic production if the private sector is unable to upgrade its STI capabilities sufficiently quickly.

The country has made significant progress in many respects since independence in 1960, particularly in improving basic education. In terms of STI capabilities, there are cases of successful major innovation by private enterprises, often through collaboration with international firms or research institutes or with support to manage skills development and technology transfer. New technologies from abroad have been successfully introduced in cases such as iron ore mining (with the national mining company, SNIM, proving able to develop the capabilities to adopt and basically master these technologies), milk and yoghurt production by private local firms and fisheries management (with satellite surveillance of fishing boundaries and scientific methods for monitoring fish stocks). However, although limitations in the availability of data render benchmarking a very difficult task, current STI capabilities are clearly in general terms weak and need to be significantly strengthened.

The NSIs are also ineffective and suffer from major shortcomings that create extensive systems failure. The infrastructure and finance needed to support domestic innovation, while under active development, remain problematic and deficient. The instances of successful innovation by private enterprises tend to be exceptional rather than commonplace, although minor innovations are likely to be much more common. Most of the economy operates far from the technology frontier in terms of the technology used. Some relatively basic technologies (such as computers) commonplace in more developed countries have not been widely diffused, which lowers productivity and competitiveness. The artisanal fabrication industry, as an example, employs a significant number of people but retains antiquated production technologies that contribute to a very low level of productivity. Most private enterprises are micro or small enterprises with relatively low productivity levels and problems accessing finance at reasonable cost. Infrastructure deficiencies raise both production and transport costs. These together greatly constrain enterprise investment and growth.

In fact, large scientific, engineering, technological, innovation, learning and knowledge generation gaps remain – and may even be growing – compared with the most dynamic economies. For countries at relatively early stages of economic development such as Mauritania, these represent major challenges to any prospect of eventual catch-up with developed countries, as do the more traditionally recognized pillars that support the development of strong productive capacities, sustained economic growth and development. These include maintaining stable but growth-oriented macroeconomic (inflation, exchange rate, interest rates, balance-of-payments, etc.) and political environments, overcoming domestic savings and investment gaps and the foreign exchange gap to allow relatively fast rates of capital accumulation through high investment rates (in part through financial sector

development), remedying infrastructural deficiencies, building strong governance in terms of effective public administration and institutional development (in particular the rule of law and property rights), creating an enabling business environment that promotes private investment and supporting the development of a dynamic domestic private sector to build national productive capacity and export capabilities. These elements combined can create a base for the development of a dynamic private sector with strong production and export capabilities that can lead to increased productivity, diversification of production, accelerated growth, effective poverty reduction and wider economic development with accompanying improvements in quality of life.

In Mauritania, Government policies over the past two decades have targeted most of these elements. Based on the findings of this Review, the degree of success in making progress in these various areas has been uneven. Major challenges remain with infrastructure, private sector development, financial sector development, institutional strengthening (particularly the rule of law) and improved public administration and management capabilities. Macroeconomic stability has been largely achieved, although its durability may prove vulnerable to continued international financial and technical support. Recent political reforms have sought to establish a better-functioning democratic system that may increase political stability and reduce political risk. The heavy reliance of the country on natural resource activities – mining, fisheries and more recently oil – means that the effectiveness of public administration and broader governance of the economy, in particular further institutional strengthening of the system of justice and transparency in economic management, will play an important role in executing a successful development strategy. Recent Governments have tried to improve transparency in oil extraction by signing on to the Extractive Industries Transparency Initiative (EITI). Country risk, however, is high. Euromoney, for example, ranked Mauritania as having the 148<sup>th</sup> highest country risk in March 2008 out of 185 countries that it ranked (Euromoney, 2008). The savings–investment and foreign exchange gaps remain key issues, as do fiscal deficits, moderately high inflation and high nominal and real interest rates, but the country is engaged in ongoing reforms supported by the International Monetary Fund (IMF). Financial sector reform and private sector development are being pursued, and a high priority has been placed on improving the physical infrastructure. There has been extensive reform to liberalize the trade and foreign investment frameworks and to privatize State-owned enterprises (SOEs).

These diverse challenges are being actively addressed through international support and collaboration with various international agencies, financing bodies and bilateral donors. The one area where that has been accorded a low priority to date has been in building STI capabilities in the productive sectors (private industry, public enterprises and public sector services), including strengthening public administration capabilities. This is reflected in the absence to date of a coherent strategy to build these capabilities, upgrade technologically and improve the functioning of the country's knowledge systems and NSI. This represents a critical weakness in Mauritania's current development strategy.

There is at present no clear STI strategy. In fact, it appears that the country has never had one. The Mauritanian NSI suffers from many weaknesses in areas common to many Least Developed Countries (LDCs). These include very weak linkages among the different actors in the system (in particular between research institutes, universities, the private sector and Government), relatively weak human resources and public administration bases,

inadequate funding and limited scope for public sector research and development, no institutional mechanism for coordinating public research activities, very little private sector training, skills development, technology upgrading or research and development (R&D), the main university only marginally involved in innovative activities, a financial system at an early stage of development with a dearth of venture capital and seed finance for new firms or funding for SMEs, a relatively weak private sector, a limited entrepreneurial base, a weak innovation culture and generally low level of awareness (including among many enterprises) of the potential role of learning, training and R&D and weak incentives to undertake them, major hard and soft infrastructural constraints, the limited role of standards as a means of upgrading quality and skills, and a “brain drain” that drains skills and knowledge from the country with limited circulation back into the country of these skills and knowledge (“brain circulation”). The ability of the country to retain many of its most highly skilled people has proved inadequate, in part due to inadequate effective demand for these skills in the private sector. There is in some respects progress, but at a rate much too slow to close the gaps with the most dynamic economies or to produce the economic conditions that would encourage more skilled people to return from abroad.

Accordingly, despite the natural tendency of both the mining and oil industries to form enclaves with limited linkages to the broader economy, improved STI capabilities could improve their contribution to the Mauritanian economy by enabling stronger linkages to domestic enterprises, possibly developing processing activities (known as beneficiation) in mining and improving the national capacity to effectively manage and regulate the oil industry and develop the skills needed to man oil production activities. Although highly capital-intensive and enclave in nature, there is a need for STI capability development in both industries in order to benefit to the maximum extent possible. There are opportunities for knowledge flows from foreign investors active in these industries, particularly in oil, but basic skills have first to be developed to make effective absorption possible.

In mining, national STI capabilities in SNIM, and in the public sector, are relatively well developed given the long history of iron ore extraction (which began before independence) and the strong support provided for the public sector management and regulatory sides of the industry backed by external financing, notably from the World Bank. The national mining company, SNIM, can be seen as a centre of excellence and professionalism for the country. However, the maintenance of the public sector capabilities, in the form of a strong skills base that has been developed in recent years through targeted programmes, is in part dependent upon continued external financial support. Even the skills base of the national mining company is in need of replenishment to replace experienced technical staff who will eventually retire.

In the oil industry, national capabilities in engineering and in management (regulation of the industry, financial management of the national oil fund, negotiation of contracts and marketing of oil) require substantial improvement, which is natural in light of the recent nature of oil production (which started in 2006). The knowledge and skills base of both regulators and the national oil company is improving but is at a relatively early stage of development and needs to progress faster. Deficiencies in education and training in oil-related disciplines in the universities and the lack of linkages to industry are strongly apparent and call for urgent resolution. Oil transnational corporations (TNCs) have been contributing to the build-up of domestic skills in the industry through financial contributions for training, but adequate training of local personnel to man the industry is proving a challenge and knowledge flows to date have accordingly been limited. A well coordinated approach to building the STI capabilities required should be developed.

This Review suggests that policymakers representing all key Government ministries and other key stakeholders should, at an early opportunity, begin discussions on developing a realistic national strategy to improve STI capabilities and build a stronger NSI in light of their national priorities and their particular circumstances. Such a strategy will be necessary to overcome the particularly large market failures in the presence of a weak private sector and limited productive capacity that characterize Mauritania today. Indeed, all countries could benefit from a well-designed STI strategy geared towards their specific needs, with many of the most successful economies placing a high priority on STI development. For Mauritania, this strategy should form part of, and be consistent with, the country's broader national development strategy, and should feature appropriately in its poverty reduction strategy. Overcoming the gaps with more dynamic economies will require sustained effort over time to build STI capabilities while at the same time pursuing complementary policies on other critical areas that can together enable accelerated growth and development and convergence towards the developed countries.



## CHAPTER 1 - INTRODUCTION TO THE STIP REVIEW

The Islamic Republic of Mauritania (hereafter referred to as Mauritania) is a geographically large coastal country in West Africa, with a small population of 3 million people but a high population growth rate. Around 90 per cent of the country's landmass is desert: the northern part of the country is arid, with the south being semi-arid. The country spans both North Africa and sub-Saharan Africa, with a correspondingly high degree of diversity in geography, climate, ethnicity and culture. Mauritania is classified by the United Nations as a Least Developed Country (LDC). The key thrust of current economic policies is aimed at poverty reduction through the creation of a more market-based economy and a strong private sector, combined with improvements in public service provision and fiscal management. Building enhanced capacity to deploy science, technology and innovation is an imperative to support these development objectives, and this Review of science, technology and innovation (STI) policy in Mauritania was undertaken in this context.

### 1.1 Overview of Mauritania's post-colonial development

Mauritania became a French colony in 1920, and remained under French control until independence in 1960. At that time, the bulk of the population was still nomadic, with many living in the desert. The country had virtually no modern physical infrastructure, no modern economy, few economic activities and a relatively small population. Since independence, successive Governments have struggled to (a) promote the development of diversified economic activity; (b) create employment; (c) reduce poverty; (d) build a modern and adequate physical infrastructure; (e) educate the population and build human capital; (f) address a growing urbanization created through increasing rural–urban migration; (g) build a modern and properly functioning economy and a strong private sector; (h) diversify production; (i) confront challenges from environmental degradation and spreading desertification; (j) overcome the general scarcity of water and recurring dry periods, severe health issues, food insecurity and low agricultural productivity; and (k) manage a transition from long-established social traditions to a more modern society and overcome social tensions that emanate from a diverse society, strong ethnic and class divisions and high rates of poverty. These challenges have been accentuated by a fast rate of population growth (2.9 per cent).

Towards the end of the 1970s Mauritania entered a decade-long period of instability marked by military coups, ethnic clashes in 1989 and frequent cabinet changes. During the 1970s, economic policies were geared towards increased State involvement in economic activity and many industries were nationalized. Following the first oil shock in 1973, economic recession and a financial crisis in 1977 led to a series of stabilization and adjustment programmes starting in 1978. Foreign aid also increased dramatically, helping to meet the Government financing gap. The second oil shock followed in 1979. The two oil shocks and a steady decline in international iron ore prices during the 1980s created strong pressure for economic reform in order to achieve macroeconomic stability. Since 1985, successive Governments have pursued economic reform programmes with support from the IMF and World Bank and various donor countries and international agencies. Economic reforms in 1985 were followed by a structural adjustment programme in 1987 and a consolidation and recovery programme in 1989.

Following presidential elections in January 1992, there was a shift to widespread economic reforms, which accelerated towards the end of the decade. Two national poverty reduction programmes were devised in 1994 and 1998 placing primary emphasis of economic policies on poverty reduction. The Poverty Reduction Strategy Paper of 2002 (PRSP-2002), the reform programmes that replaced the IMF and World Bank structural adjustment programmes, became the reference document for recent economic policies. It sought to establish and maintain macroeconomic stability and create accelerated growth and poverty reduction through the continued development of a more market-based economy based upon the private sector as the main engine of growth. Mauritania's most recent PRSP of 16 January 2007 (PRSP-2007) covers 2006–2010 and continues the general thrust of PRSP-2002. The country has received substantial external financial and technical support from the World Bank (through its Country Assistance Strategy (CAS) programmes), the IMF (through its Poverty Reduction and Growth Facility (PRGF) programmes), the United Nations and other international agencies, donors and development banks through various development projects, official development assistance (ODA) and technical assistance projects.

A key constraint in the success of current economic policies is the underdevelopment of the private sector. Being a small economy, and with severe limitations on domestic demand potential due to its very low income level, Mauritania targets export markets as a channel for effective demand that can allow fast growth in domestic output and a source of foreign exchange. Achieving rapid export penetration has presented a challenge. In natural resource industries – minerals, fish and now oil – Mauritania has been successful in exporting, but with low levels of value added domestically due to marginal processing prior to export. This accounts for the bulk of Mauritanian exports. For other important domestic production activities – notably agriculture and artisanal production that employ most people – higher productivity levels are urgently needed to improve the welfare of the major part of the population by lifting production and standards of living above subsistence levels.

Creating new domestic industries and activities, enhancing value added in major existing export industries, and raising productivity in subsistence activities, will all depend to a large extent on the capacity to upgrade technologically, and to take up and use new knowledge to enhance existing products and processes. It was in light of this understanding that the Government of Mauritania requested a review of their overall policy and institutional capacity in science, technology and innovation (STI), with special attention to the two most technologically advanced industries in the country: mining and oil.

## **1.2 The STIP Review approach**

As argued in UNCTADs *Least Developed Country Reports* for 2007 and 2006 (UNCTAD, 2007a; UNCTAD, 2006), building STI capabilities is critical in the development of productive capacities in LDCs. They are not the sole drivers of progress, and will not on their own create increased productivity, fast economic growth, higher income and broader economic development. But these outcomes are very unlikely to be achieved in their absence. They can play an important role in economic “take-off” in countries at an early stage of economic development, in terms of a stages-of-growth development model, and are certainly central to avoiding stagnation once a take-off has been achieved.

**Defining STI capabilities and innovation** - What exactly are STI capabilities and innovation are basic questions that must be clearly understood to avoid confusion. There is no single definition of either. In the absence of single, universally agreed classifications, how we define them should be based upon the purpose of the exercise and the usefulness of a definition to aiding that purpose. This Review argues that STI capabilities should include – in addition to scientific, technological and innovative capabilities – capabilities in engineering, entrepreneurship and management. This view is based on several arguments. First, much technological innovation is actually created through insights provided by engineering-based skills and knowledge rather than science-based ones or both in combination. In terms of learning more basic production technologies engineering skills are likely to be particularly important. Second, much management and organizational innovation comes through management skills rather than scientific, engineering or other purely technical skills. Innovations in service activities, including public-sector provided services, are relatively frequently based upon management insights and experimentation. Third, successful innovation by an enterprise (or in the public sector) is often not based solely upon the introduction of new technologies, but must be combined with changes in work methods, and changing work methods entails management skills. Fourth, entrepreneurs are needed to combine the people (human capital), technology, management and finance to create viable new enterprises that are the basis for creating a dynamic and innovative private enterprise sector central to a market economy. Entrepreneurs are needed to catalyze creative ideas (the dormant phase of creativity and innovation) into actual innovation (the active phase of creativity and innovation). Entrepreneurship is likely to be especially important in LDCs given the scarcity in many LDCs of large or medium-sized domestic enterprises and the need to develop small enterprises that can successfully grow into medium-sized or large ones.

This Review takes a very broad and pragmatic approach to innovation, which can be defined as the introduction of new or improved products, or of new or improved processes and organizational methods in the design, production and distribution of goods and services. This includes mainly commercial introduction by firms but can also include non-commercial introduction, for example, in providing not-for-profit public services. It is in essence the introduction of new ideas or knowledge to the design, production and distribution of goods and services and to providing solutions to economic, social and environmental problems. The innovation may be new to the world, new to a country, new to an industry or a market in a country, or only new to a particular firm in a specific country. The innovator may be a firm, a farm, an organization or an individual, including a Government or public-sector body, although the firm is generally at the centre of technological upgrading and the application of technology to production. In the public sector, innovation may be more heavily related to management and organization, including those linked to the introduction of technologies developed elsewhere, but innovation remains important to improve services that are central to social welfare, poverty reduction and development (health and education services, for example). It should be noted that, in LDCs, innovation most often involves the introduction of foreign technologies (with accompanying management or organizational changes needed in the way they operate) to create, for example, a product or process new to the country, an industry or even an enterprise within the country.

**National Systems of Innovation** - The ability to access existing knowledge and technology (including through international knowledge and technology transfer) is critical, as is the ability to master their use and apply them to local challenges through innovation. Both the mastery of technologies and their creative application to local circumstances require human capital with sufficient capabilities to learn and understand the knowledge involved. As argued in

UNCTAD (2007a), technological catch-up in LDCs requires the co-evolution of improvement in physical infrastructure, human capital and financial systems, together with improved technological capabilities within enterprises, effective transfer (and diffusion) of foreign technologies, and more effective knowledge flows between creators and users of knowledge. This implies that technical change (or, technological development) takes place within an interlinked system of actors and institutions. At the national level, these actors and institutions, together with the linkages between them, can be defined collectively as a National System of Innovation.

Figure 1.1 is a simple schematic of a National System of Innovation, showing the main elements that make up the system and the linkages between them. The nature and complementarity of the linkages between the actors are central to the effectiveness of the system, as are elements termed “framework conditions”. The Review examines primarily policies at the national level within the framework of Mauritania’s NSI. It is argued here that despite the increasingly international nature of knowledge flows and organization of innovative activities by many TNCs and some domestic firms as well as other relevant actors (research institutes and universities, for example), that innovation systems at the national and sub-national level remain critical to the economic performance of a country.

It should be noted that the concept of a National System of Innovation, as represented in figure 1.1, was developed as an analytical approach to understanding, in historical perspective, the development of industrialized economies. It therefore needs adaptation when used as a tool to analyze current policies and contribute to future policy formulation in a developing country context. Particularly, whilst recognizing that national systems will vary, it assumes that overall, a functioning system exists: the role of the analyst is to determine the relative strengths and weaknesses of individual elements and the linkages between them. Where many of the systemic linkages (and, even some of the key actors) are sparse, or absent, as is the case in some developing countries, analysis must, to some extent, assume a notional blueprint of what the innovation system should look like.<sup>2</sup> For the STIP Review of Mauritania, the broad schematic in figure 1.1 serves as a basic conceptual framework for analysis, but with the addition of basic physical infrastructure as an important “framework” or enabling condition which, when analysing innovation systems in more industrially-advanced countries, tends to be taken largely for granted.

### **1.3 How this STIP Review is structured**

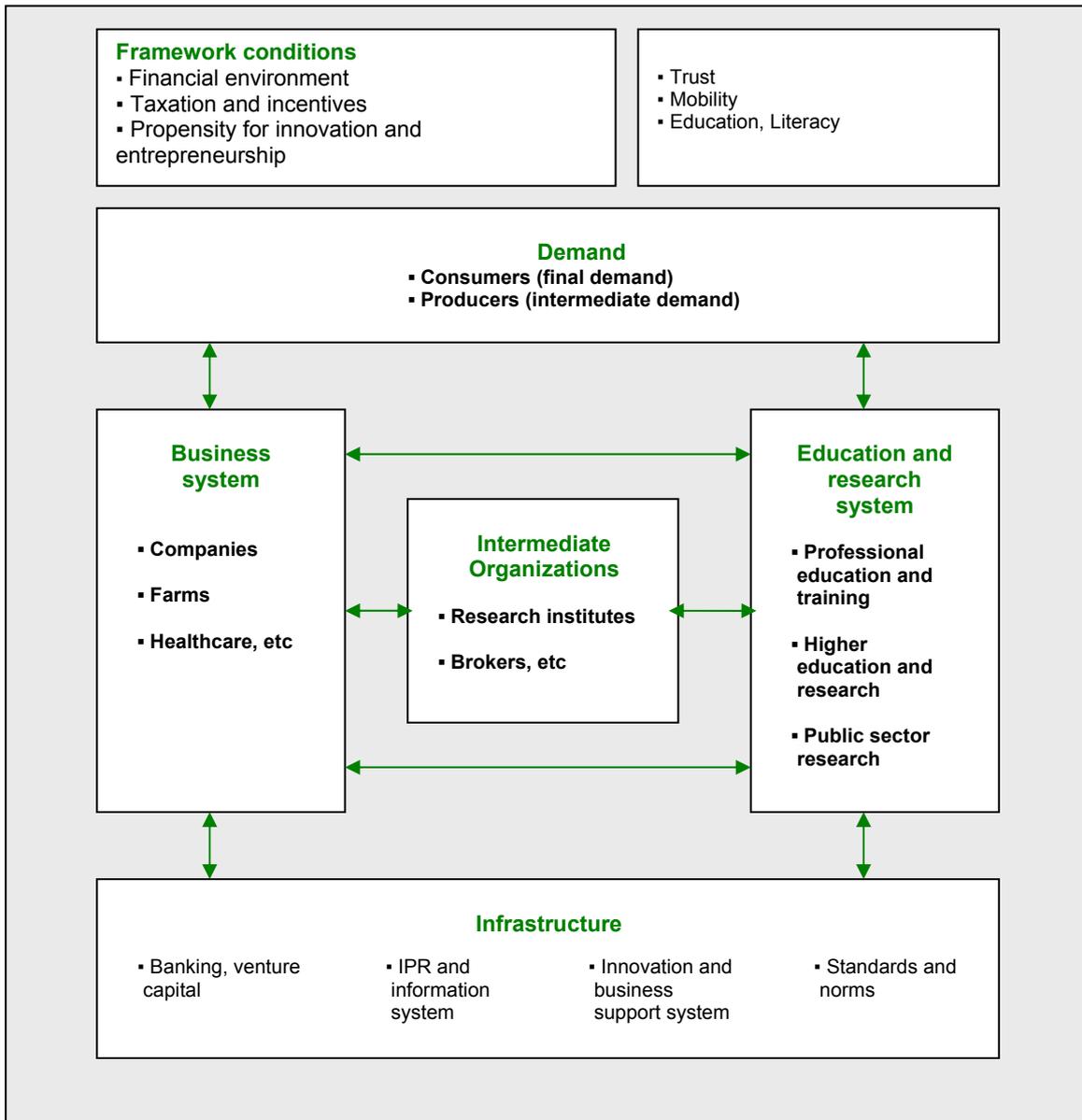
The remainder of this report is divided into six chapters. Chapter 2 presents key background information on the structure and performance of the economy in recent years, the latest social indicators, and the existing policies and institutions for STI governance. Chapters 3 and 4 provide a broad overview and analysis of the NSI, as shown in figure 1.1. Chapter 3 focuses on the STI activities of the “core” knowledge-producing and knowledge-using elements of the NSI: businesses (or enterprises), the R&D system, tertiary education, and vocational and professional training. Chapter 4 covers the enabling and framework conditions for STI capacity-building, including infrastructure, regulatory regimes, literacy and basic education, and the investment climate. Chapters 5 and 6 are devoted to more detailed

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<sup>2</sup> A good discussion of this problem can be found in Arocena and Sutz (2000). In fact, UNCTAD (2007a) argues that a National System of Innovation might be too large a unit of analysis in LDCs, and, instead, uses the concept of “domestic knowledge systems”.

analyses of STI in the mining and oil industries, respectively. Overall conclusions and recommendations are presented in chapter 7.

Figure 1.1. Broad schematic of a National System of Innovation



Source: Arnold and Bell (2001), cited in UNCTAD (2007a).



## CHAPTER 2 - OVERVIEW OF ECONOMIC, SOCIAL AND STI PERFORMANCE

In many countries, science, technology and innovation have traditionally been treated as isolated areas of policy, but it is now becoming clear that STI policies need to be fully integrated into national development planning in order to bring about technical change in key productive and social welfare sectors. This chapter provides an overview of the economic, social and policy contexts in which capacity-building in science, technology and innovation takes place in Mauritania.

### 2.1 Economic growth and production structure

Since independence in 1960, Mauritania's economy has been mainly based on livestock herding (which is possible for nomadic people), smallholder agriculture and exports of iron ore and fish. Since 2006, oil production has become a key export commodity. Directly following independence, livestock and agriculture were extremely important to the economy in terms of basic subsistence and employment, and iron ore mining very quickly developed as the main export item. Fishing developed into the second major export activity during the 1970s, particularly with the expansion in industrial fishing following the establishment of the 200 mile economic exclusion zone in 1978 and a rapid expansion in the volume of fish caught in the early 1980s (Government of the Islamic Republic of Mauritania, 1990: 3). Commercial agriculture also began to increase during the 1980s following the completion of the Manatali Dam on the Senegal River, which facilitated the development of irrigated farming (Government of the Islamic Republic of Mauritania, 1990: 3). The start of oil production in 2006 is very recent, but crude oil exports have immediately become a third major export item and a large source of Government revenue.

The growth of the mining industry in the 1960s contributed to economic growth, but the oil shocks of 1973 and 1979 and falling international iron ore prices in the 1970s (and through the 1980s) led to balance-of-payments deficits, a financial crisis in 1978 and economic recession which together resulted in a series of economic stabilization and adjustment programmes. Towards the end of the 1970s, the economy began to recover with growth of the fishing industry and a stronger mining sector, but economic activity remained subdued in the 1980s with the effects of the second oil shock in 1979 and as a result of weak demand for iron in industrial countries and the need to reduce public sector investment spending (particularly in light of a fast-rising external debt) to promote macroeconomic stability. Since independence, low rates of domestic saving have represented a major constraint to investing adequately to reduce the country's huge infrastructure deficiencies. With higher international aid and technical assistance from the late 1970s onwards, and through deep economic reforms aimed at moving to a more market-based economy, progress was made towards macroeconomic stabilization while growth remained subdued but generally positive.

Moderate (but highly variable) rates of nominal gross domestic product (GDP) growth were recorded during the 1980s. Real GDP growth during 1980–1990 was very low at 1.6 per cent, which represented negative per capita real GDP growth (-1.0 per cent) in light of faster population growth.<sup>3</sup>

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<sup>3</sup> The source of much of the data in this section is UNCTAD (2008c, 2007b and 2008a), the World Bank's World Development Indicators online database, IMF (2006a, 2006b, 2006c, 2007a and 2007b) and various national data sources, in particular from the National Statistics Office.

Selected economic indicators for the period 1994–2006 are shown in table 2.1. The table shows that economic growth was more rapid during the 1990s with real GDP growth of 3.0 per cent during 1990–2000, but this represented very slow improvement on a per capita basis with real per capita GDP growth of only 0.2 per cent. Growth in GDP slowed during 2000–2002, but since 2003 real growth has risen relatively rapidly with the recovery in international commodity prices (iron ore and fish) that have helped offset the rise in prices of imports of refined oil and food (food prices rising sharply in 2007–2008 associated with the recent international food crisis). During 2000–2005 real GDP growth increased to 4.0 per cent which translated into more rapid per capita GDP growth of 1.1 per cent. This was due in part to a recovery in iron ore and fish prices, and to increasing foreign investment that significantly boosted investment rates.

Growth rose sharply in 2006 due to the start of oil production with real GDP growth of 14.1 per cent and per capita real GDP growth of 11.1 per cent. In 2004 and 2005, faster growth was fuelled in large part by very high rates of investment (gross fixed capital formation of between 45 per cent and 46 per cent) related to intensified mineral exploration and production by foreign mining TNCs, and in particular large capital investment needed to commence oil extraction. Foreign direct investment (FDI) inflows in 2004 and 2005 were accordingly much higher than previously, at \$392 million and \$864 million respectively (and falling to zero in 2006) (table 2.1). The large fixed capital investment in these two years is reflected in large capital equipment imports. Real GDP growth in 2006 was unusually high at 11.7 per cent with the start of oil production, while non-oil real GDP growth was 4.4 per cent (IMF, 2007b). Based on IMF estimates and projections published in December 2007, growth in real GDP is estimated to have dropped dramatically in 2007 to 0.9 per cent, or -1.6 per cent in per capita terms, and was projected by the IMF to rise by 4.5 per cent in 2008 (IMF, 2007b). The actual rate of growth in 2008 may be negatively affected by renewed political instability in the country that culminated in the coup of August 2008.

Table 2.1. Mauritania Selected Economic Indicators, 1994–2006

Indicator	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Population, total (millions)	2.165	2.225	2.289	2.354	2.422	2.493	2.566	2.642	2.721	2.801	2.882	2.963	3.044
Population growth (annual %)	2.7	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.7
Real GDP per capita (constant 2000 United States dollars)	401	428	441	411	411	426	421	421	413	424	433	444	483
Real GDP per capita growth (annual %)	-5.7	6.8	2.9	-6.7	-0.1	3.6	-1.1	-0.07	-1.8	2.5	2.2	2.5	8.7
Real GDP growth (annual %)	-3.0	9.8	5.8	-4.0	2.7	6.6	1.8	2.8	1.0	5.5	5.1	5.4	11.7
Real interest rate (%)	6.4	17.0	19.8	8.9	19.2	25.7	23.9	13.6	12.3	18.1	8.5	4.3	..
Money and quasi money ((M2) as % of GDP)	16.9	14.5	12.8	12.0	11.8	11.2	11.8	12.4	12.9	13.1	..	..	..
Total tax revenues as a share of GDP (%)	17.9	17.0	17.1	15.6	13.7	14.5	13.6	12.7	13.4	12.2	13.9	..	..
Gross fixed capital formation (% of GDP)	49.0	20.3	-23.7	15.1	19.0	12.5	19.3	21.9	21.0	25.9	46.3	44.8	23.2
Total reserves (excluding gold, \$ million)	39.7	85.5	141.2	200.8	202.9	224.3	279.9	284.5	396.2	415.3	..	..	..
Total reserves (in months of imports)	0.9	1.9	2.8	4.4	4.9	..	..	1.5**	2.4**	0.7**	0.6**	1.1**	2.6**
Domestic credit to private sector (% of GDP)	26.4	17.1	17.8	17.9	17.7	19.1	23.0	24.3	26.7	27.0	..	..	..
Inflation, consumer prices (annual %)	4.1	6.5	4.6	4.6	8.0	4.0	3.2	4.7	3.8	5.1	10.3	12.1	6.2
Ouguiyas per United States Dollar Exchange Rate (End of Period)	128.37	137.11	142.45	168.35	205.78	225	252.3	264.12	268.71	265.6	256.2	268.6	268.6
Real effective exchange rate (12-month % change; end of period)	..	..	..	..	..	..	..	4.5	-9.3	-13.4	8.0	8.8	-2.9*
FDI inflows (Net, \$ million)	2.8	6.8	-0.4	-3.3	-0.3	15.1	40.1	76.7	67.4	101.9	391.6	863.6	-3.4
Gross domestic savings (% of GDP)	35.6	12.5	-33.2	7.5	3.4	-1.1	-8.6	3.1	-1.9	-4.9	-3.0	-15.0	18.7
General Government final consumption expenditure (% of GDP)	11.5	10.6	11.0	10.7	11.8	20.4	25.8	23.6	22.2	30.1	21.8	22.6	19.9
Current account balance (in % of GDP)	..	..	..	..	..	..	..	-11.7	3.0	-13.7	-34.6	-47.2	-1.3
Exports of goods and services (% of GDP)	22.2	37.0	35.0	30.6	44.3	41.5	46.2	33.8	33.2	27.6	30.5	35.8	54.5
Exports of goods and services (annual % growth)	4.9	3.9	-1.0	-16.4	-0.6	4.9	1.4	-1.6	-6.7	-11.5	9.0	6.2	117.8
Net barter terms of trade index	..	102	94	103	103	104	100	103	104	102	113	164	177
Export unit value index	..	139	135	140	124	110	100	102	100	105	116	176	208
Import unit value index	..	136	144	136	120	106	100	98	96	103	103	107	117

Sources: World Bank WDI Online Database (April 2008); IMF IFS Database (April 2008); IMF (2007a, 2007b); UNCTAD (2008c).

\* Denotes preliminary estimate or projection.

\*\* In months of following year's imports of goods and services, excluding oil exploration/production and other mining (copper, gold)-related activities, and imports financed by FDI and aid.

### 2.1.1 Composition of national output

The main changes in the composition of economic output over the past 20 years is a rise in the contribution of the services sector (mainly construction, transport and telecoms) and a reduction in the primary sector and in manufacturing, but not industrial production overall (see table 2.2). Mining now accounts for the bulk of industrial production. Mining itself has experienced a reduction in its contribution to output since the 1960s when the economy was virtually a mono-export economy. In recent years, mining production has varied with the performance of iron ore operations by SNIM, with important impacts upon overall growth rates. With the development of industrial fishing during the 1970s, the economy developed into a dual-export economy. Since February 2006, with the start of crude oil production, there has been further improvement in export diversification to three main exports. Based upon preliminary data, the development of copper and gold production by foreign mineral companies has begun to add more significantly to the country's mineral production and export basket in 2007 and 2008.

**Table 2.2. Sectoral contribution to GDP 1993-2005 (Per cent)**

Sector	1993	1995	1997	1999	2001	2003	2005
<b>Agriculture and fishing</b>	34.8	34.1	30.4	28	24.6	25	21.2
<b>Mining</b>	9.4	10.3	11	12	10.9	8.3	14.2
<b>Manufacturing</b>	9	7.6	8.3	10.5	6	5.5	4.5
<b>Services</b>	25.6	26.9	29.6	30.5	37.2	40	36.5
<b>Public administration</b>	12.8	12.3	11.7	11.8	12.4	12.3	13.2
<b>Indirect taxes less subsidies</b>	8.4	8.8	9	7.2	8.9	8.9	10.4

Sources: IMF (2006a, 2006b).

**Agriculture** - Agriculture has grown since the 1960s, particularly with the introduction of irrigated farming in the 1980s, but has since then not developed dynamically for various reasons, including a continued high level of dependence upon rain-fed irrigation and the resulting vulnerability to weather patterns. Both total agricultural production and total food production have grown slowly since 1990, and at a negative rate in per capita terms. Agricultural production grew at an annual average rate of 1.3 per cent during 2000–2005 and by -1.6 per cent (-1.4 per cent) on a per capita basis (UNCTAD, 2008a: 141–142). Food production grew at the same rates over these periods, presumably because the bulk of agricultural production (excluding fish, which are mainly exported) is for domestic consumption. These figures conceal the variability in food and agricultural production from year to year depending upon patterns of rainfall and periodic drought that make domestic food production unreliable and render imports of food (and food aid) extremely important to safeguarding food security.

Agriculture and livestock herding represent a small part of total output, accounting for 15 per cent of GDP in 2004, with crops accounting for 2.8 per cent and livestock herding for 12.4 per cent of GDP (World Bank, 2006). Commercial herding accounts for an estimated 6 per cent of GDP and commercialized agricultural crops for 1 per cent. Much of production is not commercialized. Agriculture is therefore far less important as a source of income than are mining, oil and fisheries.

However, together they employ around half of the total population, with crops accounting for two thirds of this and herding for one third. It is also the main activity in rural areas, which have little alternative economic activity. The sector is therefore central to rural welfare and to poverty reduction. Government policies have sought since the early 1980s to develop agriculture as a means to achieving food self-sufficiency (Integrated Framework for LDCs, 2001). Mauritania is extremely vulnerable to food insecurity as a result of periodic droughts leading to poor food crop harvests combined with inadequate income and foreign exchange necessary for large scale food imports. In 2002, for example, drought and poor harvests in several Sahel countries led to food shortages in Mauritania and the onset of a severe food crisis. This led the country to appeal for urgent food aid in September 2002 to avoid mass starvation (PANA Daily newswire, 2002).

This situation has led the Government to revisit its development objectives for irrigated agriculture in order to promote an intensification of rice production, diversification of agriculture, the integration of irrigated agriculture with other rural activities, the promotion of exports, and minimization of the negative impact of farming on the environment. In support of these objectives, the Government has initiated a series of projects, the most important being the integrated irrigated agriculture programme (*Programme de Développement Intégré de l'Agriculture Irriguée en Mauritanie*) (or PDIAIM) developed and introduced with World Bank support. The PDIAIM aims to raise labour and land productivity through the implementation of an extensive reform programme. Specifically, it targets an increase agricultural value added in the irrigated areas by 7 per cent a year, with a 10 per cent annual increase in the value added on agricultural products other than rice.

Livestock herding is also extremely important for rural populations, accounting for a large amount of rural employment and an important source of rural income. It accounts for a larger share of GDP than crop production despite much lower public sector investment in the industry. Despite its importance for rural development and as a source of income for those continuing the traditional nomadic existence, the sector is not well integrated in the national economy because it is a mostly informal activity that to some degree escapes official monitoring and taxation, which explains why exports of livestock are not fully captured in national statistics. In 1985, the Government developed a programme to strengthen the sector by investing in basic infrastructure and making more readily available veterinary services that made it possible to verify the absence of major diseases and maintain animal health. These reforms helped increase the livestock herds despite periodic droughts. In 2000, the livestock was estimated to comprise 1.5 million cattle, 1.1 million camels, 5.1 million sheep and 3.4 million goats.

There are significant exports of animals and hides within the region, mostly to Algeria and Morocco for camels, and Senegal and Côte d'Ivoire for sheep and cattle. Animal hides are exported to Senegal, Mali, Ghana and Morocco. There are no meat exports to the European Union (EU), where zoosanitary standards would likely bar market access. It should be noted, however, that exports within the region could be barred by the introduction of comparable standards in those countries, which would imply the need to upgrade the quality and certification of livestock even for export within the sub-region (Integrated Framework for LDCs, 2001: 8). Therefore, upgrading of standards and certification will be needed to ensure that export markets

remain open for livestock exports in future as global standards continue to rise in food products, but also to ensure domestic food safety given that livestock meat is widely consumed in the local market. Milk and dairy product production has expanded in the country with investment in training and adequate technological upgrading achieved by several domestic enterprises. Their production of milk has reduced significantly imports of fresh and powdered milk, and may eventually open export markets for camel cheese or camel milk if producers can meet sanitary and phytosanitary (SPS) standards implemented in export markets. The main challenge to date in milk production has been the difficulty in ensuring adequate collection of milk from livestock owners.

**Fisheries** - Fisheries account for about 5 per cent of GDP but generate a much larger share of Government revenues and foreign exchange, second only to mining. It is also a major source of local employment, representing between 30,000 and 35,000 jobs. The industry is divided into industrial and artisanal fishing. Industrial fishing accounts for most of the total catch and therefore most Government revenue and foreign exchange. It is also a source of revenues from the fisheries agreement signed with the EU that specifies the fishing quota assigned to EU countries in Mauritanian territorial waters. Artisanal fishing accounts for a much smaller percentage of output, revenues and foreign exchange, but directly employs more labour (11,000 people compared to 4,000 in industrial fishing) and is less likely to seriously deplete local coastal and overall fish stocks. Industrial fishing is dominated by large, modern foreign fishing boats from EU and other countries, with some participation by smaller, less modern Mauritanian-owned or chartered boats. The largest markets for fish exports are Japan (the third largest importer of Mauritanian fish in terms of volume, but the first in terms of value), Spain, France, Italy and several Eastern European countries. African countries, particularly Nigeria, Côte d'Ivoire and Ghana, provide the third-largest market for Mauritanian fish in terms of volume, but much less in terms of value.

The key challenges for the country are to improve its ability to better monitor and manage its marine resources in a sustainable manner and to increase domestic value added through fish processing and strengthen domestic participation in the industry. An additional challenge is to ensure that offshore oil exploration and production do not endanger local marine resources or marine environment through pollution. Over-fishing of some deep water species, the cephalopods (octopus and squid), by industrial fishing boats in recent years led the Government to implement restrictions in 2000 that resulted in reduced catches and fishing income from 2000 through 2005. The Government produced an updated Strategy for the Development of Fisheries and the Maritime Economy in 2006 (Government of the Islamic Republic of Mauritania, 2006) that aims to address these issues.

The World Bank (2001: 43) finds that research and surveillance activities are well developed. The Ministry of Fisheries uses satellite technology to monitor as best possible the location of industrial fishing boats in relation to the fishing zones they are licensed to fish in, and are subject to fines if they move out of their licensed zones. Fishing limits have been designed for specific species of fish, and efforts are being made to enforce the limits, in part through the monitoring of the location of industrial boats. There is also collaboration with the Ministry of Environment on developing a plan to protect the marine environment and thereby the fishing industry.

Increasing value added through development of fish processing has been pursued by Government for several decades. Key constraints include lack of access to affordable finance in part to buy new boats for industrial fishing and to improve the fish processing factories and cold storage facilities, limited human capital and STI capabilities, deficient infrastructure in factories and cold storage, port facilities and transport networks, inadequate and expensive electricity supply and a weak institutional and administrative framework.

**Industry** - Since independence, industrial activity has expanded mainly in mining (and since 2006 oil production), but also in several other industries on a much smaller scale. Manufacturing is dominated by food products and beverages, chemicals and plastics, metal products (steel) and construction materials (table 2.3), which developed during the 1980s reportedly due to support provided through the Investment Code.<sup>4</sup> These are mainly activities requiring the application of relatively basic and mature technologies, which are generally sourced from abroad and rely heavily upon foreign expertise. The number of manufacturing or processing companies is very low, less than 100 based upon data available in the database of the Department of Industry.<sup>5</sup>

There is virtually no capital goods production in the country, although a detailed breakdown of exports indicates marginal iron and steel exports (including waste and scrap metal) and of valves, tubes, diodes and transistors which together totalled \$3.5 million (or 0.6 per cent of total exports) in 2004–2005. The mining company SNIM also produces some basic capital goods used as inputs for mining. Capital goods production activities are known for the large learning and technology spillovers to other parts of the economy. However, the positive learning and technology spillover effects of activity on such a marginal scale may not be very significant.

**Table 2.3. Manufacturing firms in Mauritania by industrial activity**

Sectors	Number
Agricultural food industry	36
Chemical and plastic	28
Building materials	9
Steel industry	10
Paper and wrapping	5
Textile, leather and skin	5
<b>TOTAL</b>	<b>93</b>

Source: Ministry of Mining and Industry (June 2007).

<sup>4</sup> Government of the Islamic Republic of Mauritania (1990: 13).

<sup>5</sup> This list is not regularly updated and some of these companies may no longer be in operation.

The manufacturing sector, which was virtually absent outside mining at independence in 1960, has not expanded dramatically and remains at a very early stage of development.

Manufacturing activities grew on average at a moderate rate between 1980 and 2000 (average annual growth of 4.3 per cent during 1980–1990 and 5.0 per cent during 1990–2000) but has declined since, with average annual growth over 2000–2006 of -1.1 per cent (UNCTAD, 2008a: 143). As a result, its share in GDP fell in 2006 (to 5.7 per cent) to its 1980 level (5.6 per cent). The narrow concentration of manufacturing production in the two major cities of Nouackchott and Nouadhibou has hindered diversification. The limited success in establishing a successful agricultural sector and the relative neglect of livestock herding has meant that basic processing activities related to these products have also limited progress in diversification.

Manufacturing is dominated by the fabrication of construction materials, mainly cement and plaster, but also tiles, steel and iron, and paint. Food products represent the second main group of manufactured products. These include mineral water, grains (pasta, couscous and others), milk and milk products, and biscuits. The processing of fish has developed on a small scale, but the vast bulk of fish exports are of whole, unprocessed fish of different types. Export data show exports of dried, salted and smoked fish exports of \$3.2 million (or 0.6 per cent of all exports) and prepared and preserved fish of \$2.3 million (0.4 per cent of exports) in 2004–2005. There were also woven cotton fabric exports of \$1.9 million (0.3 per cent of total exports) and woven clothing of \$1.3 million (0.2 per cent of exports) in 2004–2005. Processing activities altogether still represent a relatively marginal export activity, and are extremely small compared to exports of minerals and unprocessed fish. There is no medium-high or high technology manufacturing production locally.

The heaviest industrial activity is in downstream mining activities of undertaken by SNIM through such subsidiary companies as manufacture of reinforcing bars, foundry, machining of parts and plant maintenance located in Nouadhibou and production of construction materials, cement and plaster production for builders based on gypsum, located in Nouakchott. SNIM has developed substantial competences in mining and has over time diversified into downstream activities in manufacturing activities to meet its repair and more basic machinery input needs. Outside mining-related activities, manufacturing is largely for import substitution and the companies involved are mainly established in Nouakchott. Agribusiness dominates manufacturing activities, concentrating on milk and its derivatives, mineral water, pasta products, cookies, flour, cattle food, oil refining, confectionery, fishery products and deep freezing. The chemical industry is geared towards the manufacture of hygiene products (detergents and soaps) and insecticides, paintings and candles.

Many manufacturing firms are operating at relatively low capacity levels and their productivity and profitability are on average relatively low. The World Bank argues that the country will over the medium term be forced to continue to rely upon mining and fishing as their major industries, and will likely meet limited success in production and export diversification, unless massive investment is made in important infrastructures and services (World Bank, 2006: 50). With the

comprehensive liberalization of trade, it is not evident whether domestic manufacturers of tradable products will be able to produce in a competitive manner, in terms of price and quality, needed even to operate successfully in import competing activities (as opposed to export oriented manufacturing activities). However, given the small domestic market, there may remain market niches in manufacturing, particularly in activities based on plentiful local resources (such as livestock hides), that will not be exploited by foreign competitors.

Clearly, however, the economy remains extremely natural resource-dependent and maintains a very narrow commodity export base (both oil and non-oil). The heavy reliance upon commodity exports creates problems related to terms of trade losses over most of the past 30 years (although less so since 2004), vulnerability to high levels of volatility in the balance-of-payments and Government financing due to high commodity price volatility, and the potential of a resource curse whereby real exchange rate appreciation (“Dutch disease”) and rent-seeking activities crowd out manufacturing and other non-commodity export activities, reduce incentives for technological development and useful innovation, and lead to negative economic, social and political outcomes. The relative expansion in the services sector and relative retreat of manufacturing run counter to the usual pattern of development expected of a poor developing country such as Mauritania. The services sector is normally expected to rise in importance as income level rises and not before industrial development. There are clear exceptions in small low- and middle-income countries, such as small island developing States (SIDS), which often develop relatively intensively into services at relatively low income levels. In Mauritania, this pattern is at least in part a reflection of the difficulties experienced in industrial development, including upgrading along the value chain in existing activities through processing activities, but also in developing a more diversified and viable manufacturing base.

### 2.1.2 Trade performance

With a small population and very low income level, domestic demand potential is limited. International trade is therefore an extremely important channel for stimulating domestic production. Wide fluctuations in economic activity and growth rates have resulted from the narrow export base and the resulting vulnerability to external shocks. The economy is also subject to a high degree of volatility from domestic events, in particular the effect of variable patterns of rainfall on local agricultural and livestock production and domestic events in the local mining (and now oil) industry. Most local output from mining, fisheries and oil is for export and provide Government revenues and the foreign exchange needed for imports of capital goods and resulting local fixed capital formation, production inputs and consumer goods (see table 2.4). Imported products are critical to local production (fuel needed for energy and capital equipment inputs needed in all industries, including especially mining and oil (which are both very capital intensive) but also manufacturing, fisheries and potentially agriculture, transport and construction) as well as consumption (especially imported food products). (See tables 2.5 and 2.6.)

Table 2.4. Mauritania exports by product group, 1995–2006 (\$ thousands)

Product group	1995	2000	2005	2006
<b>Total</b>	509,349	342,806	556,397	1,258,686
<b>Primary commodities, including fuels</b>	485,146	227,957	519,316	1,171,380
<b>All food items</b>	269,485	71,211	137,711	356,377
<b>Agricultural raw materials</b>	276	3	19	142
<b>Ores and metal</b>	195,502	156,743	381,584	814,860
<b>Non-ferrous metals</b>	299	..	..	..
<b>Fuels</b>	19,883	..	..	..
<b>Manufactured goods</b>	9,503	1	2	12
<b>Chemical products</b>	205	..	..	..
<b>Machinery and transport equipment</b>	6,557	..	..	..
<b>Other manufactured goods</b>	2,741	1	2	12
<b>Iron and steel</b>	69	..	..	..
<b>Textiles and clothing</b>	138	..	..	..

Source: Online UNCTAD Handbook of Statistics and UNCTAD (2007b).

Table 2.5. Main Imports, 2000–2005 (Percentage of total imports)

Imports	2000	2001	2002	2003	2004	2005
<b>Equipment for mining and extractive industries</b>	26.2	28.8	23.8	26.9	67.2	65
<b>Petroleum products</b>	23.3	23.9	22.1	16.4	6.3	10.1
<b>Food products</b>	22.2	17.2	20.4	22.2	9.8	9.1
<b>Other</b>	28.3	30.1	33.6	34.5	16.7	15.8

Source: ONS, Mauritania.

Table 2.6. Mauritania imports by product group, 1995–2006 (\$ thousands)

Product group	1995	2000	2005	2006
<b>Total</b>	455,194	353,643	1,342,035	1,073,326
<b>Primary commodities, including fuels</b>	212,214	149,444	278,561	567,044
<b>All food items</b>	107,604	66,071	137,228	268,646
<b>Agricultural raw materials</b>	2,823	1,280	3,235	6,571
<b>Ores and metal</b>	1,507	969	3,843	3,085
<b>Non-ferrous metals</b>	906	314	830	1,701
<b>Fuels</b>	100,280	81,122	134,253	288,741
<b>Manufactured goods</b>	242,815	144,706	1,063,177	505,334
<b>Chemical products</b>	19,405	10,799	32,235	48,237
<b>Machinery and transport equipment</b>	151,423	89,359	905,595	257,543
<b>Other manufactured goods</b>	71,987	44,547	125,346	199,553
<b>Iron and steel</b>	10,707	6,858	23,956	22,826
<b>Textiles and clothing</b>	12,276	5,981	13,146	28,469

Sources: Online UNCTAD Handbook of Statistics and UNCTAD (2007b).

The trade balance has during the past 10 years been basically balanced, with a marked rise in the value of both exports and imports in 2005, 2006 and 2007. The terms of trade are heavily affected by the prices of Mauritania's few key exports – iron ore, fish (and now crude oil) – and key imports – refined oil and petroleum

products, construction materials and equipment, and food products. The foreign exchange import cover has remained at marginal levels in recent years, indicating that the foreign exchange gap represents a binding constraint on import ability, binding capital equipment imports, local fixed capital formation (and associated embodied technology transfer) and possibly binding food and energy imports and thereby creating food and energy insecurity as well. Mauritania remains at an early stage of economic development, subject to the two classic savings and foreign exchange gaps that serve to reduce the country's potential growth rate.

In 2004–2005, iron ore and concentrates accounted for 49.5 per cent of exports (in value terms) and fish products (mainly unprocessed fish) for 44.6 per cent (UNCTAD, 2008c). Very recently, exports of copper have also become substantial, accounting for 30 per cent of all mineral exports in the first quarter of 2008 compared to 62.1 per cent for iron ore (ONS, NTCE 2008). In 2006, oil became the largest export item in value terms, but quickly fell back with declining oil production due to technical difficulties in production and initial overestimation of oil production potential. In the first quarter of 2008, minerals accounted for 56.9 per cent, crude oil for 22.5 per cent and fish for 20.4 per cent. Other exports were marginal, representing 0.1 per cent of all exports (ONS, NTCE 2008).

In 2005, imports were dominated by machinery and transport equipment (67.3 per cent), fuel (10.0 per cent) and food (10.2 per cent). This represented an unusually large importation of machinery related to mineral and oil investment. In the first quarter of 2008, a more traditional import pattern had been re-established with machinery and transport equipment accounting for 31.7 per cent, food (mainly cereals, milk and milk products, and cooking oil) for 27.4 per cent and fuel for 22.5 per cent. Food imports accounted for 32.9 per cent of all food consumption in the country on average during 1996–2001 (UNCTAD, 2008a: 79) and this proportion has remained high in recent years, but varies significantly with variations in local food output. Imports of food rose markedly during 2006, and especially so during 2007 and the first quarter of 2008. The spike in international food prices and the inability to meet domestic food requirements led the Government to institute an emergency plan in 2008 to reduce the impact of soaring food, animal feed and electricity, gas and water prices through subsidies and price limits among other measures.

The overall terms of trade (in net barter terms) were virtually unchanged over 1995–2003, after which export prices began to rise much more rapidly with fast-rising prices for Mauritanian iron ore and other minerals since 2005 and gradually rising prices for Mauritanian fish since 2006 (as evidenced by price indices for these commodities provided in the ONS (BTC, 2003)). The country has also benefited from rapid price increases in crude oil exports since the start of production in February 2006 despite a gradual but steady decline in oil production since the start of exploitation (ONS, NTCE 2008). Mauritania has therefore benefited from windfall gains from rising export prices since 2003 even though overall export volumes did not rise appreciably before 2006 and the start of oil exports. The dramatic price increases in refined oil and food commodities during 2007 and 2008 likewise may have led to deterioration in the terms of trade in late 2007 and early 2008, in addition to creating a humanitarian crisis in terms of heightened malnutrition among the poor. This contributed to increased social instability due to inadequate access among the poor.

The country's production and export structure reflects a mild crowding-out effect operating through a heavy reliance upon the rents generated from natural resources – mineral, marine and oil endowments – that has in effect crowded out the development of other areas of production and exports. With limited human capital, financial capital and public administration capacity, a huge effort has been focused on developing these industries. Fewer resources have been available for, and much less effort has been expended on, rural development or building a manufacturing base. Large foreign exchange earnings from oil exports could potentially also serve to crowd out non-mineral, non-fish exports through real exchange rate appreciation as discussed below. This structure also reflects a difficult operating environment for enterprises and farmers. This type of outcome is not uncommon among African LDCs, many of which have experienced marginal progress in industrialization, with a stagnant manufacturing base, and at the same time achieved only limited agricultural development or even agricultural decline (UNCTAD, 2006; UNCTAD 2007a).

**The balance of payments, debt, the exchange rate and international financing -**

The balance-of-payments position has remained under pressure throughout Mauritania's recent history, with recurring trade deficits in most years and a large external debt accumulated over the 1980s and 1990s. Financing has therefore been a key constraint on growth – both in terms of mobilizing domestic resources and in terms of generating adequate foreign exchange reserves to meet import needs and debt payments. A reduction in external debt in June 2002 under the Heavily Indebted Poor Countries (HIPC) initiative has facilitated an improved external debt position, with the debt service/exports ratio declining from 18.5 per cent in 1985 and 25.3 per cent in 1990 to 9.3 per cent in 2003, 6.8 per cent in 2004 and 3.7 per cent in 2005 (UNCTAD, 2008a: 171). The country is pursuing debt relief by bilateral and multilateral creditors to ensure a fully sustainable external debt position (IMF, 2007b). Still, the country has since the 1980s been heavily dependent upon external assistance via foreign aid. Large current account deficits were recorded in recent years, rising to 47.2 per cent of GDP in 2005, with a significant recovery in 2006, achieved in part through reduced imports, with a deficit equivalent to 1.3 per cent of GDP (as shown in table 2.1). Gross foreign exchange reserves as reported by the IMF (excluding oil reserves) have barely kept pace with rising imports with an import cover of just 0.6 months in 2004 and some improvement afterwards with a cover of 1.1 months in 2005 and 2.6 months in 2006.

There is a possibility that large oil revenues may allow a significant improvement in the balance-of-payments and foreign exchange reserves, although a rapid rise in foreign exchange reserves could produce excessive monetary expansion and lead to high rates of inflation and real exchange rate appreciation that can reduce international competitiveness and undermine the development of non-oil exports. The Government, with IMF technical support, has created an oil fund in part to avoid monetary instability of this kind. So far there has been little evidence of significant real exchange rate appreciation in recent years (see table 2.1) although domestic monetary conditions have been strongly expansionary and the rate of inflation rose sharply from 5.1 per cent in 2003 to 10.3 per cent in 2004 and 12.1 per cent in 2005 (see table 2.1) due to the sharp rise in economic activity, in particular oil exports and foreign exchange earnings. The foreign exchange earnings from oil exports have been in part channelled into an oil fund in order to reduce monetary

expansion to levels that can be absorbed without macroeconomic destabilization and to smooth out economic volatility that will arise from volatility in export earnings related, inter alia, to commodity price changes and also to provide a future source of revenue following depletion of oil resources.

In fact, the Ouguiya (local currency) exchange rate has since 2005 been pegged to the United States dollar, which has meant a depreciating exchange rate versus the euro, which is the currency of Mauritania's largest trading partners (France, Spain, Italy, Germany and Belgium). Asian countries (especially Japan and China) are also major trading partners, while trade relations with the rest of Africa are less significant in value terms but important in fisheries, agriculture and livestock. Exchange rate trends in recent years have therefore maintained export price competitiveness internationally in its major export markets. The obstacles to establishing manufacturing activities therefore do not appear to include an uncompetitive exchange rate or increasing real exchange rate appreciation. The country is reportedly moving towards creating a more freely floating exchange rate (IMF, 2007b).

It should be noted that maintaining a competitive real exchange rate does not affect to a great extent exports of iron, fish or oil, the main export items. These are all industries in which production levels are strongly related to national policies on natural resource management (especially for marine resources) and technical and capacity production constraints in addition to natural resource management policies (for iron and oil). For iron production, the national mining company (the sole producer) has been operating at full capacity over the past decade, which means that changes in the real exchange rate have no effect upon production (World Bank, 2006). Other industries for which exchange rate changes can make a large difference in export price competitiveness are manufactures, which are marginal in size, and agriculture and livestock (including processed products derived from them), which are again limited by supply side constraints that reduce the effectiveness of price signals in creating significant domestic production changes. These supply-side constraints relate to limited productive capacity resulting from a weak private sector, limited access to affordable finance, deficient physical infrastructure and weak capacity to instigate and manage technical change. These STI and STI-related capabilities are, in large part, the subject of this Review.

### **2.2 Social indicators, demographics, employment and poverty**

Mauritania has experienced dramatic demographic changes characterized by a large scale conversion from a nomadic lifestyle in the 1960s towards a more settled lifestyle in rural and especially urban areas through large desert-urban and rural-urban drifts. The nomadic population has declined from 75 per cent in 1965 to 36 per cent in 1977, 12.2 per cent in 1988 and 4.8 per cent in 2000 (United Nations Development Programme (UNDP)/Food and Agriculture Organization of the United Nations (FAO) 2000; UNDP, 2007). The rural population has steadily fallen, from 93 per cent in 1960 to 85 per cent in 1970, 73 per cent in 1980, 60 per cent in 1990 and 59 per cent in 2006 (World Bank, WDI online). This has mirrored a corresponding rapid urbanization over the same period. The urban population has steadily risen,

from 6.9 per cent in 1960 to 14.6 per cent in 1970, 27.4 per cent in 1980, 39.7 per cent in 1990 and 40.6 per cent in 2006. The poverty rate has declined over time from 56.6 per cent of the total population in 1990 to 50 per cent in 1996, but was very high at 46.7 per cent in 2004 and far above the Millennium Development Goal (MDG) target of 28.3 per cent by 2015. It is also very uneven, with the bulk of extreme poverty found in dry rural areas while a smaller (but still significant) amount of poverty is found in the rural areas near the Senegal River and also in urban centres. Unemployment, estimated at 32.5 per cent of the working population in 2005<sup>6</sup> (26 per cent in 1988)<sup>7</sup> remains a major problem, particularly among the youth.

Poverty is very unevenly distributed within the local population, being more widespread and severe in rural areas (which account for about 80 per cent of the poor) than in urban centres (which account for the remaining 20 per cent) (Integrated Framework, 2001). It is particularly severe in dry rural areas (where 75 per cent of farmers are poor) as opposed to the rural areas near the Senegal River (where 61 per cent of farmers are poor), which has more organized irrigation for agriculture and livestock production. Some 70 per cent of the population in rural areas is poor, compared to 21 per cent in Nouakchott and 39 per cent in the other cities. Farmers and agricultural workers account for 40 per cent of the poor. Among farmers and farm workers, 54 per cent of whom are poor, poverty is again not evenly distributed. Among shepherds, 72 per cent are poor, for cereal farmers 56 per cent, for vegetable farmers 53 per cent and among fruit farmers 34 per cent (Integrated Framework, 2001).

Explanations for continued widespread poverty include the inability of the economy to expand quickly enough in labour-intensive activities to create adequate new employment. Underemployment in marginal, subsistence activities is also a significant problem. The bulk of rents created in the economy come from mining and oil, which are capital intensive and provide limited employment opportunities (as well as relatively little scope for linkages with the domestic economy), and from industrial fishing which is similar in character (although artisanal fishing, in contrast, is more labour intensive). Primary sector activities including agriculture and livestock rearing (and artisanal fishing secondarily) along with informal sector enterprises are the largest employment activities in the country.

Employment statistics are poor, but employment trends diverge significantly from the contribution of major activities to output because of the widely differing labour intensity between mining, oil and industrial fishing, and other activities such as smallholder agriculture and livestock rearing, artisanal fishing, other artisanal activities (fabrication of handicrafts and trinkets for sale, masonry and other crafts), informal sector micro-enterprises and the public sector civil service. The majority of the population is employed in agriculture and fisheries, but various reports indicate that a large proportion is involved in non-commercial farming, artisanal fishing and artisanal production. There is also a large informal urban business sector comprised of some 100,000 micro-enterprises. There is apparently no real business sector in rural areas, reflecting the low degree of economic development outside urban

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<sup>6</sup> ONS (2007).

<sup>7</sup> UNDP/FAO (2000: 12).

centres that helps explain the large incidence of poverty in the former. It is understood that productivity levels are relatively low in many of these activities, leading to low income and purchasing power and a low standard of living for the bulk of the country's active population. Petty trading activities in urban centres are another source of employment, but the extent of this is unknown.

The improvement in poverty indicators since the 1990s was accompanied by an improvement in other indicators of social welfare as well, such as reduced child malnutrition, improved adult literacy and a marked increase in primary school enrolment. Mauritania's human development index (HDI) has therefore improved during this time period. Its HDI nevertheless remains low, with a human development ranking of 137 in 2005, the latest ranking available from UNDP, although they are not noticeably weaker than some comparator countries (see table 2.7). Its HDI indicators are, however, the lowest in the Maghreb area.

In summary, whilst the Government has done much to tackle the basic human development needs of the population, progress is severely constrained by the underlying and interrelated problems of income poverty for a large proportion of the population, low or negative economic growth, and unemployment/underemployment. Therefore, a key objective for STI is the extent to which it can contribute to the creation of new income-generating activities, in addition to addressing other social goals such as improved health.

Table 2.7. Human development indicators for selected countries (2005)

Country	HDI rank	HDI	Life expectancy (years)	Adult literacy rate (% aged 15 and older)	Combined enrolment ratio (primary, secondary and tertiary education) (%)	GDP per head (PPP in United States dollars)
<b>Mauritania</b>	<b>137</b>	<b>0.550</b>	<b>63.2</b>	<b>51.2</b>	<b>45.6</b>	<b>2,234</b>
Algeria	104	0.733	71.7	69.9	73.7	7,062
Egypt	112	0.708	70.7	71.4	76.9	4,337
Ghana	135	0.553	59.1	57.9	50.7	2,480
Kenya	148	0.521	52.1	73.6	60.6	1,240
Libyan Arab Jamahiriya	56	0.818	73.4	84.2	94.1	10,335
Malaysia	63	0.811	73.7	88.7	74.3	10,882
Mali	173	0.380	53.1	24.0	36.7	1,033
Morocco	126	0.646	70.4	52.3	58.5	4,555
Senegal	156	0.499	62.3	39.3	39.6	1,792
South Africa	121	0.674	50.8	82.4	77.0	11,110
Sudan	147	0.526	57.4	60.9	37.3	2,083
Tunisia	91	0.766	73.5	74.3	76.3	8,371

Source: UNDP (2007).

Note: Malaysia is included in the above table as an out-of-region comparator with a relatively strong STI performance among developing countries more broadly.

## 2.3 STI performance and the policy environment

This final section in the chapter presents a broad introduction to the STI situation in Mauritania. The country's performance against internationally-recognized basic indicators of STI performance is considered, and the development of governance institutions for STI in Mauritania over recent decades is outlined.

### 2.3.1 STI performance indicators

Traditional measures of innovative activity, to the limited extent that it is possible to assemble reliable data, indicate a weak performance in Mauritania relative to comparator countries. Reliable data do not exist on the most widely used indicators of innovative effort, spending on R&D and the number of researchers in the private and public sector and universities. The only estimate available on R&D spending (following extensive discussions in-country and scanning of available documents on the country) is a figure mentioned in discussions and based upon a presentation on knowledge and innovation in Mauritania of gross expenditure on R&D in Mauritania of 0.4 per cent of GDP. It was not clear how this figure had been calculated or how reliable it might be, so it cannot be relied upon. It is close, however, to the magnitude of figure often attributed to LDCs in general as representing in broad terms their level of investment in R&D. Using this figure places Mauritania ahead of Egypt but behind Morocco, Tunisia and Malaysia (see table 2.8).

It is likely that most (or even all) of this is R&D financed and undertaken by the public sector, unless R&D undertaken locally by TNCs is included in this figure. Indeed, if R&D by foreign TNCs is included then the figure would perhaps be larger than 0.4 per cent of GDP in 2003, 2004 and 2005, given the large investments by mineral and oil TNCs in mineral and oil exploration in 2003, 2004 and 2005 and the small size of total GDP. If 0.4 per cent is accurate, it remains a low figure, especially given the small size of GDP (\$2.7 billion in 2006) which means that in absolute value terms R&D would be approximately \$108 million.

For the number of researchers, if one takes the figure of 500 known research and technical staff in research institutes and the university (see chapter 3) as an estimate, this produces an estimate of researchers to population (166 per million population) that is less than half that of comparators such as the Sudan, Morocco, Libyan Arab Jamahiriya, Tunisia and Malaysia (table 2.8). This figure should only be taken as a very rough estimate given the unavailability of reliable and up-to-date data. The figure of 500 may significantly overstate the actual number of researchers by including technicians and others not directly involved in research activities. Indeed, the Government of the Islamic Republic of Mauritania (2005a: 20) reports there being fewer than 300 researchers in Mauritania, producing a ratio of researchers to population of about 1 in 10,000. The Mauritanian diaspora abroad represents a significant additional skills base, with reportedly over 100 researchers in foreign laboratories (Government of the Islamic Republic of Mauritania, 2005a: 16). There is very little formal R&D in the domestic private sector (Government of the Islamic Republic of Mauritania, 2005a: 15), although it is likely that there is some informal R&D that is simply not recorded or widely known to exist. Related to this,

there is (as noted elsewhere) relatively little formal professional training in the domestic private sector.

**Table 2.8. Selected STI indicators and countries (1996–2005)**

	GERD (% of GDP) 1996-2003	Number of patent applications by residents <sup>a</sup>	Number of patent applications by non- residents <sup>a</sup>	Number of researchers and technicians in R&D (per million population)
<b>Mauritania</b>	<b>0.4<sup>b</sup></b>	..	..	<b>166<sup>c</sup></b>
Algeria	..	58	455	
Egypt	0.19	428	2,016	
Libyan Arab Jamahiriya				854
Malaysia	0.69	179	6,272	356
Mali	..			
Morocco	0.62	139	520	782
Senegal	..			
Sudan	..			394
Tunisia	0.63	56	282	1,047
World	2.28			..
Low-income countries	0.73	7,548	13,251	..
Middle-income countries	0.85	139,418	147,313	725
High-income countries	2.45	806,062	407,808	3,781

Sources: SESRTCIC (2007), Government of the Islamic Republic of Mauritania (2005a).

Note: GERD – Gross expenditure on R&D.

<sup>a</sup> Most recent year for which data is available from World Intellectual Property Organization (WIPO), Industrial Property Statistics.

<sup>b</sup> Estimate based on discussions with various officials in Nouakchott.

<sup>c</sup> Estimate based on 500 domestic researchers (from table 3.4).

In terms of actual innovation, traditionally this is measured, although very imperfectly, by patent data.<sup>8</sup> On this measure, Mauritania records a weak innovation performance. The only data available are applications to the AIOP, a regional African organization on intellectual property (table 2.10), that indicate only two patent applications from Mauritania in 2004 and one in 2005. This is similar to several other francophone African countries in the subregion (Burkina Faso, Mali and Togo) but trails the best performers in the group (Cameroon, Senegal and Benin) and is far behind the African leaders which include Egypt, Morocco, Algeria and Tunisia (table 2.8). UNCTAD's (2005: 114) innovation capability index (an average of its technological activity index and its human capital index) ranks Mauritania as having a very low innovation capability.

The performance in scientific, engineering and technical areas based on scientific and technical publications (adjusted for population size) is accordingly very weak relative to the stronger comparators in the group, and the quality of publications, judged on the basis of the h-index also compares unfavourably (table 2.9). It is, unfortunately, even more difficult to produce data to benchmark countries

<sup>8</sup> It is often argued that patent applications are not an adequate measure of national innovative activity, especially in developing countries. Much local technological innovation may be created by the introduction of existing knowledge and technologies from abroad, or from other enterprises in the same country. Patent data will not capture this activity.

on basic technical skills in areas that are of great relevance in particular to LDCs, such as welding, carpentry, plumbing, technicians and other skills needed to develop basic industrial and manufacturing production. However, based on the discussions with various stakeholders, supported by the findings of World Bank (2007), it is clear that human resources in these technical areas are also deficient to meet current needs.

**Table 2.9. Selected S&T indicators 1996-2005**

	<b>Tertiary students in science, engineering, manufacturing and construction (% of all tertiary students)*</b> (a)	<b>Scientific and technical journal articles published 1996-2005</b> (b)	<b>Scientific and technical journal articles published Per million population 1996-2005</b> (b)	<b>Scientific and technical journal articles published 2005</b> (b)	<b>Scientific and technical journal articles published Per million population 2005</b> (b)	<b>h-Index**</b> (b)
<b>Mauritania</b>	<b>6</b>	<b>138</b>	<b>49.3</b>	<b>21</b>	<b>7.5</b>	<b>14</b>
Algeria	18	4,984	156.5	862	27.1	42
Egypt	..	27,237	400.5	3,459	50.9	60
Libya	31	586	106.5	81	14.7	14
Malaysia	40	10,894	439.3	1,806	72.8	51
Mali	..	592	45.5	92	7.1	27
Morocco	21	10,035	333.6	1,176	39.1	50
Senegal	..	2,004	198.6	252	25.0	48
Sudan	..	1,070	31.8	147	4.4	27
Tunisia	31	7,453	758.2	1,437	146.2	43

Sources: (a) UNDP (2007); (b) SESRTCIC (2007).

\* Most recent year for which data is available.

\*\* The h-Index is an indicator designed to measure the quality and usefulness of publications based upon the number of times the publication is cited by other researchers. A higher score means the research is more frequently cited by other researchers.

UNCTAD's technological activity index ranked the country among the very weakest in 2001 (UNCTAD, 2005: 290). In terms of technology inflows from abroad, there are several potential market-based channels of international technology transfer for which data are widely available, including capital equipment imports (which contain embodied technology), FDI inflows (which can transfer technology (including tacit knowledge) and skills) and royalties for technology licensing. The low level of capital goods imports apart from that related to mining and oil and motor vehicles is discussed elsewhere in this Review. Apart from oil and mineral investment inflows of FDI have also been small, with the notable exception of FDI in telecoms. There are no data available on royalties. Clearly there have been technologies acquired from abroad, in mining and fisheries for example, but data is not available to provide an idea of the amount of licensing, if any, that has taken place.

However, there is relatively little manufacturing in the country, which typically requires capital equipment and specialized production technologies. There are also no high technology exports or medium-high technology ones that might require the use of more complex technologies to produce. The technologies in use in many

production activities (manufacturing, agriculture, livestock and artisanal handicrafts included) appear to be relatively basic, and more advanced foreign technologies are reportedly imported as a complete package (turnkey technology) requiring limited domestic technological effort. In addition, imported technologies (such as computer software) may not be used efficiently due to incomplete absorption related to deficiencies in technically proficient human capital. The area where modern technology diffusion appears to be greatest is mobile telephony, which is one of the easiest to use among all high technology equipment and requires little learning to master.

**Table 2.10. Number of Applications to AOIP by Mauritania and selected comparator countries**

		2004	2005
<b>Brand names</b>			
	<b>Mauritania</b>	7	18
	Benin	31	66
	Burkina Faso	42	30
	Cameroon	104	100
	Côte d'Ivoire	240	136
	Mali	29	42
	Senegal	115	122
	Togo	30	19
<b>Patents</b>			
	<b>Mauritania</b>	2	1
	Benin	7	7
	Burkina Faso	2	1
	Cameroon	27	20
	Côte d'Ivoire	3	7
	Mali	2	3
	Senegal	12	7
	Togo	3	2
<b>Commercial brand names</b>			
	<b>Mauritania</b>	0	2
	Benin	11	18
	Burkina Faso	22	23
	Cameroon	94	67
	Côte d'Ivoire	65	38
	Mali	4	16
	Senegal	3,509	3,423
	Togo	5	10

Source: AOIP Annual Report 2005.

In summary, the available quantitative data commonly used for STI assessments indicates that Mauritania's STI capacity is very weak – which is, of course, unsurprising given its status as an LDC. However, it must be noted that, in an innovation systems context, these broad indicators are not helpful in respect of policy formulation, and that more detailed and qualitative analysis is needed. The STIP Review is intended to address this need, at least as a first step.

### 2.3.2 STI governance

Reportedly, the earliest effort to pursue an integrated approach to R&D or science and technology (S&T) policies was in 1971, with what was then the Ministry for Planning and Research entrusted with the coordination of various embryonic research activities, and then in 1973 an inter-ministerial Committee set up with the aim of putting forward a policy on S&T. The Committee, chaired by the Director of the *Ecole Normale Supérieure*, was to report directly to the President. However, the Review team did not find any official record of these events, and no official S&T policy was ever developed.

The year 2000 witnessed the emergence of the first concrete signs that research and innovation (not STI as such) were gaining increased recognition in Government policy with the establishment of an innovation award, the Chingutti Prize (prix Chingutti) for innovation, the promotion of an exhibition devoted to innovation and the establishment of a Society of Inventors and Innovators. Further recognition came in 2001 with the establishment of a Secretary of State in charge of New Information and Communication Technologies (New ICTs) reporting to the Prime Minister. The focus here was clearly on ICTs, an area of great importance, but clearly not equivalent in scope to STI, or even to technology, which is already broader in scope than ICTs. STI policies have never been placed under the purview of any single ministry or public body. In fact, public research has traditionally been dispersed among various different ministries with little or no institutional arrangements for the coordination of research undertaken in the country, or of a national strategy or policy on research, was also noted by the International Development Research Centre (IDRC, 2005). In 2002, a conference of Mauritanian diaspora research scientists working and living abroad was organized with the goal of forming linkages with them and finding a way to leverage their presence abroad to build international research linkages.<sup>9</sup> Also in 2002, UNDP funded the organization of consultations between the Government and private sector, with different Government ministries meeting with the chamber of commerce, to establish a dialogue on the constraints faced by the private sector. The linkages between them have apparently not been maintained.<sup>10</sup>

As part of the Government restructuring implemented during 2007, the position of Secretary of State in charge of New Information and Communication Technologies was converted into a department under the newly created Ministry of Water, Energy and ICTs. The ministerial department is therefore clearly targeted at ICT development. The logical argument in support of this structure appears to be an acknowledgement that ICTs are a cross-cutting, platform technology that can be considered as an important element of the production infrastructure, as are water and energy. However, it has the obvious drawback of a focus on ICTs without any emphasis on technological development more generally. While ICTs are extremely important, other technologies, and the more general issue of technological capabilities, especially in agriculture, fishing, manufacturing, artisanal crafts, oil and

<sup>9</sup> According to the Government of the Islamic Republic of Mauritania (2005a), the results were disappointing due to lack of funding to pursue any sort of follow-up to the conference.

<sup>10</sup> Based upon discussions in Mauritania.

minerals, health and environment, remain crucial for poverty alleviation and reduction.

In 2004, a Department of Scientific Research (DRS) was for the first time created within the Ministry of National Education. Government also established in 2004 the National Fund for the support of Scientific Research (FNARS) (*Fonds National d'Appui à la Recherche Scientifique*) with the aim of financing specific research projects within the higher education system of Mauritania (see box 2.1). The DRS was moved in August 2005 to the newly created Ministry of Higher Education and Scientific Research, thus giving increased visibility to research activities and increased recognition of the need for coordination. The role of the department was to ensure the coordination of the various public research activities being undertaken in different areas and under various different ministries and ministerial departments. However, the degree of effectiveness in coordinating research has been undermined by a lack of human and financial resources (IDRC, 2005: 25). The need to improve the public management of resources and ensure improved coordination appears to be relatively widespread throughout the public sector based on discussions with various stakeholders. The National Programme for the Development of the Education Sector (PNDSE) aims, among other things, to develop research units, encourage cooperation in research, improve the financing of research (through establishment of the FNARS research fund) and encourage international research collaborations. These represent some elements of what a national strategy for research would consider.

Under a Government restructuring plan in 2007, scientific research was centralized within the new Ministry of National Education as a sub-branch in charge of scientific research and academic affairs. There was a separate service created specifically responsible for scientific research, whose main role was “to ensure the coordination and monitoring of scientific research activities”.<sup>11</sup> The Department for Scientific Research has several roles including increasing the value of scientific research output, developing scientific research, following up and assessing research programmes and pursuing international scientific co-operation.

The Department is charged with the following specific tasks: (a) development of scientific research within university; (b) management of cooperation programmes in the field of research; (c) coordination of the research programmes; (d) distribution of research means between the various colleges of higher education; (e) assessment and follow-up of the research programmes and the concomitant achievements; (f) monitoring of the arrangements for the scientific demonstrations; (g) promoting innovation in technology and scientific research; (h) making suggestions, within its own competences, on the orientations in the scientific research policies and mobilization of the appropriate means for their achievement in relation with the research elements in higher education; and (i) making suggestions on the policies to implement within the framework of the funds and research projects.

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<sup>11</sup> From Ministry of National Education website at <http://www.education.gov.mr/NR/rdonlyres/37202E7E-BE63-4CC8-B090-02F21989F5A6/0/CompositiondelAdministration.doc>.

**Box 2.1. The National Fund for the Support of the Scientific Research (*Fonds National d'Appui à la Recherche Scientifique (FNARS)*)**

FNARS was created in 2004 within the framework of the National Programme for the Development of the Education Sector (PNDSE) under its higher education component with the aim of promoting scientific research in the higher education system. This was to be achieved through incentives and the structuring of higher education research and the financing of scientific and technical projects as well as scientific journals.

Their budget for 2006 was \$330,000 with financing provided by Government (20 per cent), the International Development Agency (IDA) of the World Bank (40 per cent) and the African Development Fund (40 per cent).

The FNARS secretariat is organized through the Scientific Research Executive Board, and comprises a coordination committee, a management committee and specialized technical commissions.

In 2005, FNARS contributed to the financing of 24 research projects in various fields such as ecology, education, natural resources preservation, pedagogy, health and culture. Only three projects were related to pure applied sciences and benefited from a FNARS contribution. These included a project on the development of medicinal herbs, another on the development of clays, and a third on the design of new phosphates building materials with high value added.

In light of the small budget, the funds should be targeted very carefully into applied R&D in projects that are expected to have very high financial and social rates of return in terms of helping provide solutions to pressing economic and/or social and environmental problems. The fund could, for example, aim to be a source of co-financing with the private sector on specific projects in order to leverage financing and establish linkages that are currently reported to be very weak between research in the education system and the private sector. This would imply careful prioritization of projects in light of the project possibilities and national priorities, and with a clear focus on the usefulness of the R&D in achieving a high rate of return. Ideally, linkages would be established even more widely between the University of Nouakchott, the private sector, public research centres, other public sector or private research centres in other countries and where useful, with international agencies and non-governmental organizations (NGOs) working on specific related issues. While very small, it would be ideal if the fund could help build useful linkages that may otherwise not develop. This could help build a stronger knowledge system and NSI in the country. If this could be achieved, and the fund could show positive results, then donor countries might be more willing to allocate a part of their aid into funding for an expanded FNARS.

Sources: Ministry of Higher Education, Government of the Islamic Republic of Mauritania (2005a).

In the past, owing to the limited financial and human resources available to the department, the DRS has, in spite of its various specific official roles, largely restricted itself to the development of strategic studies and training programmes, and management of the FNARS research fund. Due to its recent creation, it is not clear exactly what operational roles the research service will actually play, and whether its role will in reality continue to be limited in nature as it has been in the past.

The elements that STI encompass are far broader than research, including among other things, policies and organizations related to R&D and education and training (both formal and vocational) – which together comprise human resources

development – but in addition various other types of policies and organizations as well as institutions. The merging of research oversight with education has logical synergies given the centrality of human resources development and training to STI capabilities, the obvious need for the former for providing competent researchers. Synergies would arise from the fact that the main university in Mauritania, Nouakchott University, accounts for a large part of total national research. Indeed, Government of the Islamic Republic of Mauritania (2005a) indicates that they account for the major part of all research in the country.

In terms of development of a national STI strategy, two important reports were issued under the authority of the Secretary of State for New Technologies. The first is the National Strategy for the Development of New Technologies of 29 November 2001 (Government of the Islamic Republic of Mauritania, 2001b). The second is the Action Plan for the Promotion of Research and Technological Innovation in Mauritania issued in 2005 (Government of the Islamic Republic of Mauritania, 2005a). It is notable that discussion has generally focused relatively heavily on ICTs with less emphasis on other production technologies. The 2001 National Strategy presents a “first version” of a strategy specifically for ICT development (not for technologies in general) for the period 2002–2006. Discussions with various stakeholders indicated that the strategy has to a large degree seen only partial follow-up with regard to implementation of most elements of the strategy.

The 2005 Action Plan for the Promotion of Research and Technological Innovation presents a study on the state of research in Mauritania, focusing in particular on ICTs but going much further to research in general. While not a national development plan for STI, the report does present a useful analysis of some of the constraints to reversing the declining interest in technical studies in the education system, to increasing the amount of research undertaken and to improving the usefulness of research that is actually done. It also makes several suggestions on how to improve the research performance and the usefulness of research in Mauritania, particularly with respect to ICT development. There does not appear to have been active follow-up to many elements in the report to date, which was confirmed in discussions on the ground. The issue of Government implementation – or rather the lack of implementation – of strategies and plans that have been developed in the past was widely noted in discussions as an important one.

In conclusion, STI policy and institutions can be seen to be underdeveloped at the present time in Mauritania. The only ministry that has direct responsibility for STI is the Ministry of Education, and perhaps as a result STI policy has so far concentrated very much on education and scientific research. Technological development and the diffusion of innovations receive little policy attention, other than in relation to ICTs. In addition, policy implementation appears to be a serious problem for Government. Based on discussions with various people, this appears to be partly due to high rates of turnover of management in Government ministries and a resulting lack of continuity in the planning and implementation of many projects, a lack of documentation on implementation that can be passed on to new managers and a lack of funding needed to implement projects that are not in some way donor funded.



## CHAPTER 3 - STI CAPABILITIES IN BUSINESS, HIGHER EDUCATION, TECHNICAL TRAINING AND RESEARCH

This chapter presents an overview and analysis of the STI institutions and activities in Mauritania that are at the core of a national system of innovation: these are businesses, research organizations, professional and higher education and training, and specialist organizations or arrangements for linking businesses to STI activities in the public sector (as shown in figure 1.1 in the introductory chapter), and to international sources of technology.

### 3.1 STI and enterprise productivity

A good indication of productivity levels among manufacturing enterprises in Mauritania is provided by the World Bank (2007), which studied the productivity of a sample of manufacturing firms during 2005.<sup>12</sup> On average, productivity, or value added, per employee is \$3,042 and labour costs are \$1,506 among manufacturing firms studied. The study documents that productivity levels per employee are lower among smaller enterprises than in larger ones (with the exception of firms in construction materials), and that lower productivity is closely correlated to lower wages in the former. However, as the labour productivity of larger firms exceeds the degree to which wages are higher, they have slightly better unit labour costs than do smaller firms. There are also lower capital–labour ratios (or capital intensity) and lower rates of utilization of total production capacity among smaller enterprises than in larger manufacturing firms. Indeed, the study indicates that capacity utilization is relatively low for manufacturing enterprises in Mauritania in general across manufacturing activities (at 62 per cent), although still higher for larger ones. Further, while noting the technical difficulties inherent in making international productivity comparisons, it finds that labour productivity is relatively low compared to some comparator countries in the region with a relatively good performance (such as Kenya, Nigeria, Mali and Senegal), although higher than some others (including Rwanda, Uganda and the Gambia). Further, labour costs appear to be high relative to many other low-income sub-Saharan African countries. The combination of relatively low productivity and relatively higher labour costs leads to uncompetitive unit labour costs for firms operating in the country in general. This renders firms uncompetitive relative to those in many other countries and makes absolutely essential the need to raise labour productivity.

It also finds evidence that capital intensity in production is low in Mauritania relative to many comparator countries, which is unfortunate given the likely need to raise capital intensity by investing in appropriate machinery and equipment, in addition to improving training and the skills base of employees, in order to increase labour productivity. In addition, capital productivity also appears low relative to comparators, which may imply that machinery and equipment are used relatively

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<sup>12</sup> The low level of productivity and most of the constraints identified in that report were confirmed in discussions with various stakeholders in the preparation of this Review, including private and public sector enterprises, Government officials and others in the country.

inefficiently (due perhaps to inadequate training and skills and incomplete absorption of the technology) and/or that production levels are too low to achieve the economies of scale needed to make production efficient. It is also possible that the equipment is old and outdated, poorly maintained or not appropriate to production needs. The study undertakes statistical exercises to estimate multi-factor productivity and concludes that it too is low relative to comparators in the region (and elsewhere) with a relatively good performance.

These findings help explain the lower rates of productivity in very small firms, which are less likely to use efficiency enhancing equipment and technology or to have higher education and skill levels among managers. In fact, they go further and help explain why the private sector has not expanded dynamically, and why productive capacity remains a serious obstacle to improving the supply response that would allow firms to take advantage of market access to exploit more heavily export opportunities. The vicious cycle of low firm productivity leading to low profitability, low rates of investment (in business expansion, building STI capabilities, equipment and technology acquisition) and therefore continued low productivity levels into the future may be the reality for many Mauritanian enterprises. Enterprises caught in such a cycle are not able to upgrade over time, become more competitive and expand their operations. Under conditions of intensified competition from imports (in tradable activities) and/or foreign investors producing locally, such enterprises may be vulnerable to becoming financially unviable and face forced closure. The study indicates that 25 per cent of manufacturing firms studied had reported that they were experiencing financial losses on their business operations, reportedly the highest proportion among sub-Saharan African countries for which recent investment climate surveys had been undertaken recently. These are the microeconomic firm level dynamics that underlie a weak private sector dominated by micro- and small enterprises subject to a weak human capital base and STI capabilities, severe financing constraints, inadequate physical infrastructure (electricity and transport in particular) and high unit labour costs. They struggle to attain higher levels of productivity and profitability needed to prosper in increasingly competitive markets. Higher productivity levels are in general needed to allow higher profitability and make possible higher internal savings and investment rates by firms. Such a profit–investment nexus is particularly important in a country like Mauritania where access to outside sources of finance is a major constraint for many micro- and small enterprises.

Productivity per employee in enterprises with between 5 and 9 employees (categorized as very small enterprises) is \$2,727 while that in enterprises with between 10 and 40 employees (small enterprises) is \$3,237 and in those with 50 or more employees (medium-size and large enterprises) is \$7,582. The corresponding labour cost (a good indicator of wage rates) per employee is \$1,291 for very small enterprises, \$1,480 for small enterprises and \$1,942 for medium-size and large enterprises. Due to very low productivity, salaries account for a larger share of total output in very small enterprises (59 per cent) than in small ones (41 per cent) or medium-size and larger ones (46 per cent), which means that profitability (output less wages, as an indicator of overall expenses) is likely to be lowest in the smallest enterprises.

Evidence of the positive effects of higher STI capabilities and the greater use of technology on productivity levels is also provided by the study. Productivity per employee is found to be far higher in enterprises using higher levels of capital technology, with those using the Internet recording productivity per employee of \$4,683 and those not using the Internet \$2,670 per employee. Compensation to labour in the former is also higher, although not proportionally to the higher productivity level. Those enterprises using the Internet also have much higher capital-to-labour ratios. Likewise, productivity per employee in enterprises managed by more educated managers is much higher. In enterprises managed by someone with a university education, productivity is \$5,059 per employee, for those with a professional education \$3,023 and for those with a secondary school or lower education level \$2,832. The study finds that productivity is higher in exporting firms than those producing for the domestic market (\$4,627 per employee versus \$3,023) and also far higher in foreign-owned enterprises than in those owned by Mauritians (\$7,582 per employee versus \$3,023). Exporting firms are expected to have higher productivity, and this is a common finding, although the direction of causality should not be automatically assumed to run from export orientation leading to higher productivity. Foreign-owned manufacturing firms are likely to be more productive because they are probably those with more highly educated managers, using more labour-enhancing equipment and technology, meaning that these firms may tend to have stronger STI capabilities and better technology. They may also have easier access to finance and links to foreign markets that can facilitate production and sales.

There are a number of factors that account for the limited dynamism of the Mauritanian private sector. It is dominated by microenterprises and small enterprises with relatively few domestic medium size or large enterprises, and a small number of large (or extremely large by local standards) transnational corporations (TNCs) active in the country. This pattern, often termed the “missing middle” pattern, is typical of LDCs (UNCTAD, 2007a). The informal sector is composed of over 100,000 microenterprises operating mainly in urban areas (World Bank, 2007). Breaking out of this market structure presents a challenge. While smaller firms can be relatively innovative compared with some larger enterprises, in Mauritania they face large challenges and are likely to be too small to exploit any economies of scale. The experience in LDCs tends to confirm that microenterprises and small enterprises generally do not grow into larger enterprises (UNCTAD, 2006).

Challenges to domestic enterprise development in Mauritania include physical infrastructure deficiencies that add to production and transport costs, difficulty in access finance at a reasonable cost, difficulty in acquiring the skilled workers needed (reflecting the generally weak human skills base), relatively high domestic labour costs and low labour productivity, the absence of business support mechanisms and high tax rates. Also, based upon discussions, private enterprises are mostly run with a very short-term planning horizon, with more of a trading mentality than a manufacturing one. This may be accounted for by the traditional cultural dispositions of a formerly nomadic populace. Being mostly traders, business owners may be less inclined to enter into manufacturing activities, which require longer-term planning horizons to become successful. Another potential consequence may be that

entrepreneurs may not value training or R&D, which are less important in simple trading activities which do not require major technological progress and skill development as a basis for success in generating profits. Similarly, the motivation for major investment and reinvestment in the enterprise may be less strong, which may make it more difficult to create a dynamic savings-investment nexus. The three companies studied in the Review that managed to successfully undertake major technological innovations all had to invest relatively heavily in creating new skills and in accessing (existing) knowledge and equipment for the business. For these enterprises collaboration with others outside the firm and financial support were important (see boxes 3.1, 3.3 and 3.4).

Microenterprises in particular face severe challenges in operating competitively and generating the revenues that would create high rates of profits that could be used for reinvestment to grow the enterprise and create additional employment. This is likely to be the main source of finance available to most of them given the current level of development of the banking and financial system, although microfinance institutions are being developed. They are often subsistence operations with low productivity, low profits and low investment rates, which contrasts with the type of profit–investment–growth dynamic (or profit–investment nexus) that characterizes many successful firms in fast growing industries in some of the most dynamic developing economies. It is likely that various types of support services will be needed to build the private sector.

It should be noted that the study finds significant variation in productivity among firms in different manufacturing activities (agricultural processing, wood and furniture, printing and others), as would be expected. It should also be noted that the study argues that the findings on low productivity actually apply not just to the manufacturing sector, but to other sectors within the economy as well. The study lends support to the arguments presented in this Review on the role of education and training as well as infrastructure and finance, in addition to other elements, representing key reasons for low productivity in Mauritania. The failure to adequately upgrade STI capabilities has played a major role in undermining the productivity and dynamism of the Mauritanian private sector. The case of the enterprise MIP Frigo (box 3.1) illustrates the point for fishing, where few fisheries companies have managed to upgrade STI capabilities to increase value added locally by processing fish. Achieving significant productivity improvement across diverse activities within Mauritania requires stronger STI capabilities, and therefore appropriate national policies to promote their development.

### **Box 3.1. MIP Frigo: innovation to add value in fisheries**

MIP-Frigo is a medium-size majority Mauritanian-owned enterprise and part of the MIP (Mauritienne des Industries de Peche) group. MIP Frigo, part of the group, is a small fishing company established in 1999. It is 60 per cent owned by the group and 40 per cent owned by the French food services group Saros la Criée, which manages chain restaurants in France. The partnership with Saros has eased market access for MIP in exporting fish products. Most fishing companies in Mauritania export fish without any type of processing resulting in very low value added locally. MIP Frigo is one of a number of fish companies that entered fish processing. To do so successfully meant that the company had to upgrade its capabilities. They are today famous in Mauritania for its deep-frozen and pre-cooked fish products that are exported to the EU.

Fishing is not a traditional activity in Mauritania, given that before independence the bulk of the population was nomadic. The Mauritanian people are not, therefore, natural fishermen, and acquiring training in fishing techniques is relatively important for success. Fishing nevertheless developed as an important industry given the natural bounty of abundant fish species off the large Mauritanian coast. Most of the fish were frozen whole and exported without any type of processing. The Government has sought to promote fish processing to increase the value added and generate additional employment.

MIP Frigo decided to begin fish processing for export based upon fish supply by small scale artisanal (as opposed to industrial) fishermen. The requirements in terms of knowledge, skill and equipment (a factory with processing facilities and freezing equipment) required significant investment. In order to export fish, companies must meet the technical and sanitary standards in place in the importing countries. In the case of MIP Frigo, with its export markets mainly in France, Spain and Germany, this meant the need to meet EU sanitary and phytosanitary standards (SPS) on fisheries which relate to micro-organisms (microbiological standards), traceability and labelling requirements and other aspects of food safety and require HACCP (Hazard Analysis and Critical Control Point) compliance. In addition, Saros maintains its own standards for fish products it imports and required the company improve its quality standards accordingly. This meant that the company had to upgrade its skills base, technological capabilities and technology (actual equipment) to ensure that they met these standards by providing adequate cold storage facilities (freezers) and ensuring appropriate laboratory accreditation of food safety standards in Mauritania.

Saros acted as a channel for technology transfer by training 15 Mauritanian staff in quality standards. The training involved one week in an agronomic research centre in France followed by additional follow-up training. In order to ensure continued access to European markets, MIP Frigo pursued ISO certification 9001/2000, but this required further technological upgrading through additional training. The domestic fish quality certification body (CDM2) reportedly provided assistance that was useful for the company in eventually achieving certification. In addition, the company sought technical assistance from the European Union under its EU–African, Caribbean and Pacific Group of States (ACP) partnership programme, established in 2002 as part of the EU–ACP private sector development strategy. The project proposal's technical assistance requests were to train personnel in terms of hygiene, quality control and food security, provide technical assistance for updating products and to conduct a periodic audit and implement ISO 9001/2000 certification.

Following the EU–Economic Community of West African States (ECOWAS) Agro-Industrial meeting in Dakar, Senegal in November 2002, the company's project proposal was accepted and under the EU Proinvest programme a technical assistance programme was implemented in collaboration with the EU's Centre for the Development of Enterprises (CDE). The project to improve quality control started in January 2004 and was completed at the end of 2004. It included the optimization of an HACCP-based food security system for the company, implementation of a certification and tracking procedure and the completion of procedures for an audit of ISO pre-certification. As a result of the various channels of technology transfer, MIP Frigo attained ISO 9001/2000, the only Mauritanian fishing company to achieve this certification even though other companies are also still active in fish processing. As a result, the company has been able to guarantee continued access to the EU as an export market as far as current standards on fish products are concerned. The challenge is to upgrade other fish company's in the same manner to allow similar access.

MIP Frigo's efforts to upgrade the company's capabilities were successful due to the investments dedicated to training and the ability to secure a partnership with Saros and the support of the

Proinvest programme and CDM2 in technological upgrading. It required a major internal effort along with external technical support. While several other Mauritanian fish companies continue to process fish for export, many others that had tried to begin processing have reportedly returned to exporting unprocessed fish because of the difficulties involved in upgrading their technology to allow processed fish exports. Out of some 10 companies established during the 1980s, 8 were either shut down or are operating below capacity because of high production costs, the lack of adequate harbour facilities and unavailability of qualified manpower. As a result, only a fraction the factories built for fish freezing and processing remain in active use. This illustrates the uncertainties surrounding investments in technological upgrading and innovative activity, and the need for technical support for enterprises with limited capabilities but promising potential to successfully upgrade to meet international standards. It is not clear whether the implementation by Government, via IMROP (which is responsible for certification of fish safety), of higher standards domestically would promote other company's to upgrade their capabilities, and what assistance could be made available to facilitate such upgrading.

The case also illustrates the practical difficulties in companies with limited capabilities and resources successfully moving up the value chain into higher value-added activities. Generally rising fish prices did not automatically elicit a large supply response in Mauritania among domestic fishing companies, or automatically lead to upgrading along the value chain into higher value activities. Indeed, the supply response has been heavily constrained by several binding constraints. One is access to finance. This is in general a severe constraint in Mauritania, cited most commonly by local enterprises as an obstacle to running a business (World Bank, 2007). A second is difficulties in developing adequate skill and technology upgrading by many artisanal fishermen to remain in business.

Even for MIP Frigo, commercial success has not been assured by its success in technological upgrading. The company is faced now with the challenge of assuring adequate supplies of fresh fish because of the challenges that many artisanal fishermen face in remaining in the business. Reportedly, many artisanal fishermen who had obtained financing for boats and fishing equipment encountered difficulty in repaying the loans, and could not continue fishing (and thereby supplying MIP with a reliable flow of fish). This threatened to undermine the company's ability to guarantee adequate supplies to clients in Europe. In order to ensure a steady supply, MIP began financing fishermen, and even producing fishing boats with which to supply fishermen. MIP has thus expanded its activities along much of the fish products value chain. This has created additional challenges that must now be faced both in managing these financing activities as well as in managing the further vertical integration of MIP along the value chain. This means the need for further upgrading of capabilities in terms of management as well as additional technical skills in construction of fishing equipment.

Sources: Interview with company; Proinvest Annual Report 2004.

### 3.2 Higher education and technical training

Education and training are critical areas for building STI capabilities. This section covers tertiary education (more basic education is considered in the next chapter), and professional and vocational training activities that are carried out in both the public and private sectors.

**Technical and vocational training** - Training is also not very widespread among enterprises in the country. The World Bank (2007) finds that only 25.5 per cent of

manufacturing firms in Mauritania provide formal professional training, which is similar to Mali (27.8 per cent) but lower than in Algeria (31.8 per cent), Senegal (33.2 per cent), and particularly the best case comparator, South Africa (64.0 per cent). In addition, technical and vocational training opportunities are poorly developed, which means that the chances for obtaining training after the formal education system are scarce for most adults in the labour market. This is an important constraint as very few employees in the manufacturing sector have any education beyond secondary level. The World Bank (2007) reports that 7.1 per cent of all employees in manufacturing have no education, 31.1 per cent have a primary level education, 45.3 per cent a secondary level education, 12.3 per cent a technical education, and 4.2 per cent a university or engineering education. This compares similarly to Burkina Faso, but is weak relative to intermediate performers such as Cameroon, Mali, Kenya and Uganda. In Mauritania, most enterprises are family owned, and based on discussions in the country this may play a role in the low level of training activities if they reserve training only for family members. Professionally managed enterprises may be more likely to see training as a means to improving productivity.

The system of technical and vocational training comprises 20 institutions that belong to various Government ministries as well as to the private sector. As the illustrative figures in table 3.1 indicate, despite the insufficient supply of well-trained personnel, the training centres are actually running well below capacity.

**Table 3.1. Training centres under the Department of Technical Vocational Training (2007)**

Centres	Training capacity	Training specialization	Actual operation rate
Centre of technical education	170	Technicians	63%
LFTPI Nouakchott	926	Industry	83%
LFTP Nouadhibou	800	Maritime	84%
LFTPC	390	Trade	75%
LFTP Boghé	255	Agriculture	85%
TOTAL	2,541		81%

*Source:* Department of Technical Vocational Training (FTP).

The GERs at vocational and technical institutions has remained very low at around 1 per cent since 1985 until 2002/03 for which data are readily available (table 4.4). The numbers have not improved dramatically since then. Currently, some 2,500 training positions are offered by public institutions that belong to the Department of Vocational Training. Their training programmes are geared towards qualification or certification for specific jobs. The employment rate of the trainees is reportedly about 50 per cent, which is indicative of a mismatch in the types of professional qualification or the quality of graduates and the demand in the labour market. The technical and vocational training system remains a notable and critical weakness in the NSI in terms of deficiencies in the technical skills available throughout the economy. This is evident in the recent World Bank Investment Climate Assessment (World Bank, 2007) and complaints by many enterprises and other local actors in review team discussions in the country on the difficulty of finding competent technical personnel such as machine operators, welders, repair people, electricians, plumbers, computer technicians, computer scientists and technologists and engineers of various types.

These technical skills – from basic to intermediate and advanced – provide the technical skills needed for technological upgrading through effective absorption of foreign technologies, the maintenance of the physical machinery in which much technology is embedded, and technological learning (inter alia, through reverse engineering and imitation). It is worth noting that there are almost no relationships between the training institutions and industry on design of training programmes or other collaboration that could improve the adaptation of such training to their needs.

There have been discussions between Government and French donors on the possibility of establishing a semi-private polytechnic institute with campuses in Nouahidbou and Zourate to provide technical trade skills training (i.e. welding, mechanics, etc.) and potentially host higher-level technical education. The use of online or “virtual” classes would in principle be included as part of this idea, which would in theory be a major advance by making it possible to undertake training virtually wherever the appropriate ICT facilities are available, or can be made available. This could help improve the technical skills base in areas that are badly needed in the country. The issue of implementing domestic certification and standards for technical professions such as mechanics, which apparently does not currently exist, would also need to be addressed. The polytechnic institute, if it is eventually established, will likely help solve some of the basic human resource issues. Mauritania reportedly has several private training schools, but their small size reportedly prevents them from achieving the economies of scale necessary to offer sufficiently high-quality education and training opportunities to result in immediately employable graduates.

Of course, the issue of training goes beyond the most specialized training and into lower-level technical, management, administration and other types of training not geared towards research, including training for the public service, which is important to produce an effective public administration. Based upon discussion with various stakeholders inside and outside Government, training in the public service, like research, has traditionally taken place with little or no coordination between ministries and has not emanated from any strategic plan for human resources development. Each ministry has designed its own research programme in isolation, and the Ministry of Education has not been involved in any way. This may reduce the effectiveness of national development strategies and also lead to wastage of scarce resources.

**Higher education** - The number of students at the tertiary level grew from 7,527 in 1990 to 12,742 in 2000, but admission policies aimed at avoiding excessive admissions in an environment of deficient resources (classrooms and other physical facilities, equipment and qualified teaching staff) reduced enrolments to 10,844 in 2002/03 (of which 8,941 studied in Mauritania and 1,903 were on scholarship abroad). Enrolments have risen only marginally since then, to 11,711 in 2006/07 with the increase accounted for by students abroad (3,025) while the number enrolled at the University of Nouakchott declined marginally to 8,686. In addition to public university education, there exists a new private university with a total capacity of 143 students, of which 22 (15 per cent) were pursuing a scientific discipline in 2007. The private sector is the only institution to have introduced postgraduate studies in higher education in accountancy, Management Control and Business Administration.

Tertiary education, with enrolment rates in recent years of below 4 per cent, therefore occupies a relatively marginal place compared with basic education. This again limits the longer term ability of the country to upgrade its human capital base.

The University of Nouakchott is a relatively young university, founded in 1981. Previously, all higher education was from attending foreign universities. The university has four faculties: (a) law; (b) social sciences; (c) science and technology (FST); and (d) medicine. The STI disciplines of the university fall mainly under the FST. The FST, created in 1995 (through Decree 95-046 of 2 November 1995) is in charge of higher education in the fields of science and technology. Currently, 1,000 students are registered in the faculty, with two thirds opting to study in Arabic and the remainder following the bilingual system (Arab and French). This represents about 10 per cent of the total 10,000 students enrolled at the university. This is slightly higher than the 8 per cent S&T enrolment rate reported by the Government of the Islamic Republic of Mauritania (2005). This means that 95 professors teach 1,000 students, or each professor teaches 105 students, which would appear to represent an unfavourably high ratio of students to each professor. Five pedagogical divisions or departments deliver courses in biology, chemistry, geology, mathematics/data-processing and physics. The FST delivers only diplomas at the masters level. Post-Masters studies must be pursued abroad, most commonly in the Maghreb countries (mainly Morocco and Tunisia), in Europe (mostly France), other African countries and North America. About 3,000 Mauritanian students currently pursue postgraduate studies abroad. Their ability to succeed in their more advanced studies abroad indicates that the Mauritanian higher education system, while suffering from major deficiencies, does appear to equip graduates with the means to pursue additional academic studies. The creation of a postgraduate course at the university is being considered, but is likely to take time before becoming a reality given the severe resource constraints already being experienced.

The university currently offers undergraduate and masters-level degrees, although an initiative is reportedly underway to establish Ph.D. programmes. The departments within FST are Chemistry, Physics, Math, Biology and Geology. In 1995, an applied mathematics degree was created where the students could focus on engineering or economics. A “professional masters” programme was mentioned, including the following studies: agricultural science; hydrology/water management; mining geology; maintenance (dealing mostly with electrical machines); and information technology, mostly web-based. The percentage of students at the University of Nouakchott enrolled in scientific disciplines has remained low since its establishment, at 8 per cent in 1998/99, rising marginally to 11 per cent in 2006/07 (table 3.2). In 2006/07, 994 were registered for postgraduate study in scientific fields at the Faculty of Sciences and Techniques (FST) whereas more than 1,700 pursued postgraduate study in scientific disciplines at universities abroad (see table 3.3). This means that more than half of scientific students actually study in foreign institutions. The small number of students at FST results from a voluntary regulation in the flow of graduate registrations accepted due to resource constraints felt by the university more broadly.

The feedback from both Government and enterprises, particularly mining companies, regarding the quality of technical education within the university, was that students are not adequately prepared for employment upon graduation.<sup>13</sup> The most common cause cited was that the education at the university is exclusively theoretical. In terms of the content of curricula and the disciplines most pursued by students, there are additional issues that must be addressed in terms of the mismatch between the knowledge and skills being acquired and those needed by industry. Most students at the university reportedly have little interest in

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<sup>13</sup> The question of the effectiveness of education at FST was asked of many interviewees throughout the country mission.

technical disciplines, which is reflected in relatively low enrolment rates in these subjects. To some extent, this may be related to problems from the demand side of the labour market, where there is insufficient demand for certain skills, which provides a disincentive to specialization in these areas. This does not appear to be the case in Mauritania. Most enterprises interviewed during the preparation of the Review complained that they could not find adequately trained staff, especially in technical subjects (engineers, technologists, technicians and machinery operators). Some complained that an inordinate amount of training was required at the cost of the enterprise before staff could work effectively. It would be useful to investigate further the reasons for the strongly apparent mismatch in skills acquired by students and those most needed by industry. In part, the problem has reportedly been due to limitations on the availability of qualified teachers in technical subjects.

**Table 3.2. Students at the University of Nouakchott by area of study 1985–1999**

	1985/86	1990/91	1995/96	1998/99
<b>Science &amp; Technology</b>	-	535 (10%)	746 (8%)	820 (8%)
<b>Humanity</b>	1,142(27%)	1,678 (31%)	2,558(29%)	2,903(28%)
<b>Social Science</b>	1,981(49%)	2,817 (53%)	5,248(60%)	6,452(62%)
<b>Centre Supérieur de L'enseignement Technique (CEST)</b>	70 (1.7%)	97 (1.8%)	115 (13%)	113 (1%)
<b>Teacher Training</b>	876 (22%)	212 (4%)	132 (15%)	185 (1.8%)
<b>Total Students at University of Nouakchott</b>	4,069	5,339	8,799	10,473

Source: *Le système éducatif mauritanien éléments d'analyse pour instruire des politiques nouvelles*, 2000 as cited in World Bank (2001).

**Table 3.3. Students at the University of Nouakchott and abroad (2006-2007)**

	Number	%
<b>Total number of students (Mauritania+abroad)</b>	11,711	100%
<b>Total number of students abroad</b>	3,025	26%
<b>Students following a scientific discipline at masters level at FST</b>	994	11%
<b>Students following a scientific discipline at postgraduate level abroad</b>	1,754	15%

Source: University of Nouakchott.

Note: Percentages are reported in relation to the total number of students.

Inadequate financing is a major challenge for the university. Its buildings are in a state of relative disrepair, and some of the FST facilities lack laboratories, rooms and data-processing equipment. The 95 professors and researchers must share overcrowded offices and do not have adequate computers or Internet access with sufficient bandwidth to allow simultaneous connections. Remuneration is also an issue, with professors complaining of inadequate salaries as well as deficient research budgets. Pursuing a career at the university is therefore not very attractive, and some teachers search out more attractive alternatives. The infrastructural constraints are a major handicap to the creation of a dynamic pole of useful research and innovation in the country. These two elements, upgrading the physical infrastructure of the university (including ICT facilities as well as the purely physical facilities) and raising professors' wages to a level that would allow an acceptable basic standard of living are two issues to be addressed in reforming the role of the university.

The lack of linkages between the university and the private and public enterprises – and the public administration – also has consequences for the ability of enterprises (and the civil service) to find the skill and knowledge sets that they require, and likewise for the ability of many students to find adequate employment relevant to the knowledge and skills that they have developed. The deficiency of practical skills of many graduates was widely remarked upon in discussions with private and public enterprises and others. This is an issue that applies to the technical and vocational training institutes as well as the university. In Mauritania, there is clearly a need for more practically trained technical graduates who can move into technical jobs without an inordinate need for major additional training. An additional constraint that was widely noted in discussions, which applies as much to the whole education system as to the university, is the need for more foreign language skills, especially English. The lack of English language skills is apparently an important constraint in the oil industry in particular based on in-country discussions.

This mismatch between supply and demand in the labour market – meaning private enterprises, public enterprises and the public administration (particularly those requiring specialized skill and knowledge sets, such as the Ministry of Health and the Ministry of Oil and Mining) – is a classic problem that faces many countries, but Mauritania can ill afford to not effectively target the use of its resources as effectively as possible. Curricula need to maintain a balance between purely theoretical and more practical skills, with the latter achieved in part through more active linkages with enterprises – including the possibility of short internships with enterprises so that students are as fully exposed as possible to practical work environments well before they graduate and participation in teaching by enterprises where they have staff with specialized skills. This would include the TNCs active in the country, particularly in mining and oil, which are extremely important industries in the economy.

While the formal responsibility for overseeing the integration of supply and demand sides of the education and skills lies with the Ministry of National Education, it will be difficult for them to achieve this in isolation. The Ministry of National Education, the University of Nouakchott, the technical and vocational training centres, the Ministry of Employment, Integration and Professional Training (*Ministre de l'Emploi, de l'Insertion et la Formation Professionnelle*) and the Ministry of Trade and Industry should establish effective linkages amongst themselves and with the enterprise sector to design a system that will allow improved manpower planning and greater consistency between the skills produced in the system of education and the requirements of industry. To ensure that the needs of the public sector are also addressed in terms of public sector training, these linkages might also need to include other ministries such as the Ministry of Public Functions and Modernization of Administration (*Ministre de la Fonction Publique et de la Modernisation de l'Administration*) which has some oversight of training in the public sector, and other ministries with specific technical training requirements in terms of personnel (for example, the Ministry of health and the Ministry of Mining and Oil – possibly including the national mining and oil companies, SNIM and SMH, which also have specific training needs).

The only ongoing enterprise collaboration with the FST is reported to be those with SNIM (*Société Nationale Industrielle et Minière*), the national industrial and mining company. Their eight-year long collaboration has been in the areas of geology, maintenance and ICTs. SNIM reported that it is willing to collaborate with the university, especially on basic technical skill development (such as welding skills, for example). It should be noted that SNIM also relies

heavily on training staff abroad and on the job training and continuing technical training outside of the SNIM–University of Nouakchott collaboration. Ideally, the FST should benefit from the knowledge and experience of the private mining TNCs active in the country in terms of occasional lectures or seminars and other such linkages to the formation of the technical skills base relevant to the mining industry. Collaboration with private enterprises has reportedly been more difficult to arrange as some had been approached but they did not appear very interested in collaboration.<sup>14</sup>

Fundamental changes may be needed within the FST to provide much more practical education with a better mix of theory and practice. Internships at enterprises would also be useful.

**Distance education** - In terms of distance education, the only programme in existence in Mauritania is the Global Distance Learning Centre (*Centre de Formation et d'Echanges à Distance*) or CFED. The centre contains state-of-the-art computer technology and software, with high-speed Internet, as well as voice and videoconferencing, with a room equipped with 20 PCs and diverse multimedia equipment (presentation projector, software packages, video projector, cameras and interpretation booths). It features videoconferencing with VSAT link with capacity of 384 kbits/s, providing access through videoconference and Internet connection on a 24-hour basis. The videoconference room has a capacity of 50 people, equipped with dozens of portable mikes, in addition to 2 multimedia rooms with the capacity of 20 people.

Distance learning course modules can be used for training, and the centre is linked to the *Université de Laval* (Canada), offering a small select group of students a bachelor of science degree course in information technology, recognized by the Province of Quebec which will issue the diploma jointly with the University of Nouakchott. Voice and videoconferencing services permit live interaction between the students and the Laval faculty (World Bank, 2004). The centre is planned to mainly host seminars and work-shops. The centre holds great promise as a tool for accessing knowledge and skills from abroad.

### 3.3 Research and development

Formal R&D activities are usually seen, collectively, as the key driver of innovation and technical change within a country. Whilst the role of R&D is often over-emphasized in science and technology policy in relation to other essential capabilities, institutions and activities, it remains a critical area for the long-term development of indigenous innovative capacity. This section presents and analyses existing R&D capacity in Mauritania, in three categories: dedicated research institutes in the public sector, university research, and R&D in the private sector.

**Public research institutes** - There are 18 public research institutes (PRIs) in Mauritania with a total of about 500 research scientists (see table 3.4). Nine of them are attached to the Ministry of National Education and deal with areas of specialized higher learning in science, technology, technical subjects, administration, agriculture and livestock, and Islamic research

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<sup>14</sup> Based upon discussions with the Dean of FST.

The others are more specialized and address specific issues of high national priority along sectoral lines, and perform R&D in the areas of fisheries, crops, agriculture, livestock, water, environment, health, geology and archaeology under the responsibility of their respective ministries. No official data on total R&D expenditure is available. In general, the PRIs all suffer from insufficient or highly uncertain financing, with the possible exception of the National Centre of Oceanographical Research and of Fishing (*Institut Mauritanien de Recherche Océanographiques et des Pêches* (IMROP)), the best-funded PRI. The only figure on R&D spending, based on discussions with officials in Nouakchott, is the figure reported in a presentation on knowledge for development that the combined public sector R&D budget in 2004 was equivalent to 0.4 per cent of GDP or about 1.1 per cent of national expenditures.<sup>15</sup>

The PRIs all receive some degree of State financing, which means that there would automatically be an interest to ensure that the funds are used on areas of high priority. For project-specific funding by donor or development agencies, this is perhaps less of a concern if one can assume that they are interested only in funding projects considered to be useful, although this does not necessarily guarantee that the projects are of the highest priority for the country. The sources of financing are more diversified for some centres than for others, but in all cases there is very little or no private funding. The sources of funding are important in determining the potential sustainability of R&D efforts by a centre. Government financing is in general a relatively sustainable source of funding, while donor funding is perhaps less likely to be sustainable in the long term, being relatively heavily influenced by donor policies and potential changes in donor priorities over time. Financing by international institutions and development agencies may also be subject to variability in the long-term, and may vary with specific projects they are undertaking that involve a particular research centre. Private funding can also be highly variable, and would normally depend upon there being opportunities for collaboration on projects seen as beneficial to private enterprises. Only then would they be likely to finance public R&D. Currently, there appears to be no financing of public R&D by private enterprises in Mauritania.

In Mauritania, the bulk of R&D resources in terms of both personnel and expenditure is reportedly accounted for by three centres. These are (a) IMROP; (b) the National Centre of Agricultural Research and Development (*Centre National de Recherche Agronomique et du Développement Agricole* (CNRADA)); and (c) the National Institute of Livestock and Veterinary Research (*Centre National de l'Élevage et des Recherches Vétérinaires* (CNERV)). They are also the most diversified in terms of sources of financing.

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<sup>15</sup> Figure from a presentation at a workshop on 28 April 2004 in Nouakchott on "Knowledge for Development", RIM (2004).

Table 3.4. Public research institutes and researchers in Mauritania, 2007

Identification	Year of creation	Authority	Budget in \$millions	Field of research	Number of research scientists	International funding sources
<b>HIGHER EDUCATION</b>						
Centre Supérieur d'enseignement technique Higher Centre for Technical Teaching	1983	MEN	-	Education and training : Technicians, secretaries..	3	-
Institut Supérieur d'Etudes Technologiques Higher Institute for Technological studies	2007	MEN	-	Agriculture Livestock	4	-
Université de Nouakchott Nouakchott University of which: FLSH FST FSSE Faculty of Medecine	1981 1981 1995 2006	MEN	-	Renewable energy, crops, Culture, Nutrition, Animal Biology, Marine pollution Public Health	285 85 95 90 20	World Bank, France, Espagne  Canada UNESCO, AUF UNDP
Ecole Normale Supérieure	1970	MEN	-	-	49	AFDB
Ecole Nationale d'Administration (ENA)	1966	MFPMA	-	-	5	IBD
ISERI	-	MAIEO	-	Islamic research	22	IDA
<b>Total number of research scientists in higher education</b>					368	
<b>Sectoral centres</b>						
Centre National de Recherche Agronomique et du Développement Agricole (CNRADA)	1974	MAE	0,32	Crops, agriculture and training	7	World Bank, AFDB, IBD, FAO, FADES, FIDA, ADRAO
Centre National de l'Élevage et des Recherches Vétérinaires (CNERV)	1973	MAE	0,21	Livestock and training	18	World Bank, AFDB, AFD
Institut Mauritanien de Recherche Scientifique (IMRS)	1974	MCC	0,20	Anthropologie, History, Archeologie	12	European Union
Centre National des Ressources en Eau (CNRE)	2002	MHE-TIC	0,86	Water resources	10	World Bank
Office Mauritanien de Recherche Géologique (OMRG)	1980	MPM	0,82	Geology	25	World Bank
Institut Mauritanien de Recherche Océanographiques et des Pêches (IMROP) (formerly CIMROP)	1978	MP	2,8	Fishery, Environment, Training	20	AFD, UNIDO, FAO, Canada, EU
Centre National de transfusion Sanguine (CNTS)	2002	MS		Public Health	3	-
Institut National de Recherche en Santé Publique (INRS) (formerly CNH)	1978	MS	0,47	Hygiene, Public health	37	WHO
<b>Total number of research scientists in the sectoral centres</b>					132	

MS: Ministry of Health; MEN: Ministry of National Education; MAE: Ministry of Agriculture and Livestock; MP: Ministry of Fisheries; MAIEO: Ministry of Islamic Affairs and Traditional Education; MCC: Ministry of Culture; MFPMA: Ministry of Civil Service and the Modernization of the Administration; FST: College of Sciences and Techniques; FLSH: College of Arts and Social Sciences; ISERI: Institute for Islamic Science, Studies, and Research; MHE-TIC: Ministry of Hydraulic, Energy and Information and Communication Technology; AFDB: African Development Bank; AFD: French Development Bank; IBD: Islamic Development Bank; IDA: International Development Association (World Bank); FADES: Arab Fund for Economic and Social Development; ADRAO (WARDA) West African Rice Development Agency; AUF: French Speaking Academic Agency.

Sources: Ministry of National Education; Stads *et al.* (2004); IDRC (2005).

IMROP works primarily on fisheries R&D and quality control for fish exports (see box 3.2). CNRADA and CNERV, established in 1973, in Kaédi and Nouakchott respectively, concentrate on agricultural and livestock R&D. Agriculture and fisheries account for about 90 per cent of PRIs, Mauritanian researchers and a similar share of total research expenditure according to Stads et al. (2004) and IDRC (2005).

**Box 3.2. IMROP, fisheries management and fisheries standards**

IMROP, which is based in Nouadhibou, is the most important and the most active research centre in Mauritania, being allocated most researchers (half of the researchers in agriculture) and budget (40 per cent of the allowances). It was established in 1952 as the Fisheries Laboratory of Nouadhibou, becoming the National Centre of Oceanographic Research and Fisheries (CNROP) in 1978 and finally attaining institute status in 2002 (Stads *et al.*, 2004). It concentrates on fisheries research with the goal of contributing to sustainable fisheries exploitation in the country (fish being a natural resource that is renewable only if exploited without depletion beyond a certain threshold). It monitors fish stocks and pollution levels and seeks to determine whether different fish species are being overfished and action should be taken to reduce fishing of those species. Its activities are therefore central to the successful management of the fisheries industry in a sustainable manner. The industry is a major source of employment and, along with iron ore exploitation, represents the major source of production, exports and revenues for Mauritania.

IMROP also has responsibility for fish product health control. The Department for Sanitary Control Upgrading within IMROP houses the technical competences and laboratory equipment for quality control of exporters fish products and certifying that they meet EU quality standards. These standards are based on a series of EU Directives which place the main responsibility for meeting standards on the exporting enterprises. Throughout the whole fish export process, from catching the fish through to their marketing, the company must ensure that the HACCP (Hazard Analysis and Critical Control Point) principles were fully met. These Directives must be included in the national regulation. IMROP is the competent authority responsible for approving companies' procedures and issuing health certificates for the products ready for export and consumption.

According to a study carried out by the Mauritanian Centre of Policy Analysis (CEMAP, 2005a), 67 factories were approved as having met the Directives of the EU standards. These factories, operating mainly in the deep freezing of sea products, are confronted with a serious problem of raw material shortages, which is explained by the low quantities of fish landed onshore (only 10 per cent of the fish captured are landed – the rest is kept on board the fishing boats and exported directly without passing onshore). Thus the majority of them were shut down while the active ones are operating below capacity at very low utilization rates (approximately 30 per cent). Moreover, inspections revealed serious deficiencies in the level of the conformity with the EU SPS standards in the ships and in cold storage and processing factories. This exposed the country's fisheries exports to a serious risk of the closure of their main foreign markets in the EU. More recent inspections by EU inspectors noted a major improvement in SPS standards among Mauritanian exporters.

The introduction by the EU in January 2005 of product traceability rules put additional pressure on the industry, especially as traditional fishing boats and production equipment also became subject to EU SPS standards. IMROP therefore has an important potential role in providing support to promising fisheries enterprises that need technical assistance to build STI capabilities and upgrade their standards to meet HACCP principles in the way that MIP-Frigo was able to do (see case study of MIP). As illustrated by the case of MIP-Frigo, support services will likely be necessary to facilitate this.

CNRADA has a long history of agricultural research in Mauritania, having taken over the agricultural research activities of the former French Colonial Fruit and Citrus Institute (IFAC), which established the first research station in the country in 1952 and the French Tropical Agriculture and Food Crops Research Institute (IRAT) that conducted research in the country between 1960 and 1972 (Stads et al., 2004). The issue of having CNRADA and CNERV operating separately has been raised in the past, and a merger of the two was planned but eventually did not take place. CNRADA nevertheless benefited from World Bank funding of agriculture projects such as the World Bank supported Integrated Development Project for Irrigated Agriculture in Mauritania (IDPIAM) that started in 2000 aimed at improving agricultural value-added, income and employment opportunities for the Mauritanian population living in the Senegal River Valley. The project allocated over \$2 million for R&D activities to be carried out by CNRADA in collaboration with CIRAD and WARDA. The R&D activities are focused on very practical aims reportedly including the improvement of new pumping systems, the testing of equipment, and studying farmer acceptance of new techniques for draining and lowering salinity developed by researchers (Stads et al., 2004; World Bank, 1999). This is the type of highly applied R&D that can have a strong positive development impact by helping address problems faced by farmers by providing technological solutions to improve productivity.

Despite Government funding of all centres, the total financing of the centres has reportedly proved insufficient for all except these three. Even for CNRADA and CNERV, funding for research has been highly dependent upon development projects being implemented. Most centres have as a result been forced to spend the major part of their budget on management of the centre, salaries and basic activities with relatively little left for the development of actual R&D activities. This is also a problem, albeit to a lesser degree of severity, for both CNRADA and CNERV, according to Stads *et al.* (2004). Government funding alone is insufficient to cover the research programmes of CNRADA, CNERV and IMROP, but these centres have managed to attract financing from additional sources. The funding of both CNRADA and CNERV has nevertheless reportedly in the past been in doubt following the cessation of a World Bank supported project on agricultural services that ran from 1995 through 2000 (le Projet des Services Agricoles or PSA) (Stads *et al.*, 2004), illustrating the vulnerability of the centres to continued financing by development agencies and donors. Stads *et al.* (2004) reports that a number of researchers left CNRADA and CNERV following the end of the PSA project, illustrating the limited career prospects of researchers and the negative effects of the completion of large development projects on research employment opportunities in the domestic economy.

IMROP is the best funded PRI due to financing related to negotiated fisheries agreements, notably that with the EU of 2002. As part of that agreement, the EU agreed to fund fisheries R&D, vastly increasing the funding available to IMROP. Because of this, they have a budget of over UM 700 million (Euros 2 million) and have a staff of 250 including 110 researchers and technicians as well as two oceanographic research boats and two monitoring laboratories. It is the only truly adequately funded research centre in Mauritania.

The centres generally have collaborative research arrangements with research centers in other countries, which is critical in view of their limited operating budgets. CNRADA and CNERV, for example, collaborate with institutes in Senegal, Mali and Morocco, and each has linkages with various other institutes. IMROP collaborates with various West African fisheries research centres and European research institutes (Stads *et al.*, 2004).

However, there is little coordination or collaboration among the PRIs themselves. In terms of linkages with the private sector, there is no funding from private enterprises, but CNRADA reportedly has worked in close collaboration with the Mauritanian Association of Agriculturists and Stockbreeders and CNERV has conducted research on behalf of the Association of Milk Producers, the National Group of Pastoral Associations (GNAP) as well as the private enterprises Tiviski and Toplait (Stads *et al.*, 2004).

There appear, therefore, to be fairly extensive research linkages between the PRIs and foreign PRIs and some degree of linkages between them and the domestic productive sectors. The latter appears to have been largely driven by World Bank development projects aimed at rural agricultural development, which are by nature linked to the needs of rural populations. The challenges appear to be in coordinating and monitoring the different research activities of the PRIs to promote synergies where possible and knowledge sharing, as well as establishing research priorities. The degree of direct coordination and collaboration among the institutes themselves may not need to be great if they have very different specializations that overlap little, but even in such cases inter-disciplinary discussions and networking can at times be useful even if only as a source of new ideas from different perspectives. A big challenge remains how to ensure more reliable and secure financing for research. This is a difficult question faced by most developing countries. The FNARS research fund goes part of the way to improving the sustainability of funding, but its budget is limited and it is in principle a limited duration fund that will operate for only five years. Increasing enterprise financing of R&D undertaken by PRIs through joint projects would represent another part of the solution, and has been pursued as a policy goal in many developed and developing countries alike. Fiscal policy measures, such as tax incentives for R&D by enterprises, are a standard policy tool widely used by other countries and can be used locally.

**Research at the University of Nouakchott** - The University of Nouakchott is the main university in Mauritania, although two other small private universities have been established, and was created relatively recently, in 1981. Its central role in contributing to human resources development is clear, and it has made significant progress since that time in terms of the number of students educated. It also plays an important research role, along with the PRIs, and still accounts for a major part of the skilled research base of the country, as noted in Government of the Islamic Republic of Mauritania (2005a) and IDRC (2005). It also pursues various international collaborative research efforts. But it has contributed only very marginally in supporting the development of a strong NSI in terms of establishing linkages with private and public sector enterprises (and with Government) – which constitute the productive sectors of Mauritania – and acting as a major source of innovation. It thus acts largely as a very traditional education institution existing mainly to provide education services to students.

This general lack of linkages between researchers and enterprises, noted in the 2005 Action Plan (Government of the Islamic Republic of Mauritania, 2005a: 15), represents a key constraint to building a stronger knowledge system and NSI in the country and to creating the wave of technological upgrading and technological innovation that is needed in Mauritania. The lack of effective linkages with industry is also an issue for public research institutes, as discussed in the next section. The weakness in these linkages is often a problem in LDCs in general, where “sparse, often disconnected R&D activities have little if any links with the needs of domestic enterprises or farmers organizations” and where “the dearth of linkages

between formal public research institutes and domestic production dissipate the considerable inputs already invested over the years” (UNCTAD, 2007a: 57; UNCTAD, 2006: 251).

There is official Government recognition in some sense that the university is a key institution in developing a more innovative economy. A Government ruling adopted in 2006<sup>16</sup> stipulates that “full command of the development of sciences, technology and know-how through research and innovation should be among the higher education objectives”, but the university has not so far acted as an effective engine of innovation. The Dean of the FST also realized that the university holds a central role for the diffusion of an innovation culture, commenting that the “development of research and innovation cannot be conceived without the direct involvement of the University”. Indeed, given that the university houses the bulk of technical researchers in the country, it must play a central role in providing useful R&D and in spurring technological innovation.

The university undertakes research mainly funded by the recently established research fund FNARS under various faculties, but research has reportedly not really been institutionalized to date, and inadequate financing for research has been a limiting factor. IDRC (2005) found that the time spent by most research professors on research was too little, and that too few professors were actually engaged in research on a full time or half time basis to produce optimal research results. The university’s research has to date been heavily skewed towards theoretical rather than applied subjects, with fundamental (theoretical) research reportedly accounting for over half of all research they produce, whereas the ideal situation would be channelling the bulk of their research effort (say, 75 per cent) to applied research targeted at solving actual problems.<sup>17</sup> This would promote increased innovation, although additional effort would be required to ensure that some of the applied research could be either commercialized or put into use on a non-commercial basis to address issues related to environment, health and infrastructural deficiencies, for example.

It should be noted that there is no objective way to assess the actual quality of the research given the lack of official evaluation of R&D undertaken at the university. By the most demanding measure of new patents created, research has not been very successful. In terms of the number of publications produced, there is no known data for the university or its departments. But these measures are not necessarily the most useful in any case. The usefulness of the research in solving real problems is the best measure, but again there is no data available to measure this. The active pursuit of international research collaborations and the many research collaborations apparently in place with foreign universities may indicate that useful research is taking place, and that domestic resources and knowledge are being leveraged. IDRC (2005) reports that projects in various areas including the environment, desalination of sea water, renewable energy, urban and rural studies, food technologies and ICT were being pursued with universities in France, Spain, North America and African countries including Algeria, Morocco, Senegal and Tunisia as well as various research networks. This type of international collaboration is in principle very desirable to leverage scarce resources, promote synergies where possible and benefit from learning and international knowledge sharing.

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<sup>16</sup> Ruling (Ordonnance) n°2006-007/CMJD of 20February 2006.

<sup>17</sup> Based upon discussions with the Dean of the FST and several university professors.

The current focus on fundamental research further weakens the potential of the institution to act as a dynamic engine of innovative activity. This is critical as the University has over 300 researchers, which represents a large share of all active Mauritanian scientists in the country based upon available data. Of these, about 100 are professors or researchers within the Faculty of Science and Technology (FST- Faculté des Sciences et Techniques). Initiatives to induce more applied research and consulting for industry among faculty reportedly began in 2007, but there is no data available on which to judge their level of success.

**Private sector R&D** - Given the early stage of private sector development and predominant market structure, it is not surprising to find that there is relatively little formal R&D undertaken by the private sector. The only known official Government report specifically on research and technological innovation in Mauritania reported research to be nonexistent in the private sector (Government of the Islamic Republic of Mauritania, 2005a: 15). This is likely to mean that private sector enterprises undertake little or no formal R&D. From discussions with various actors, this clearly seems to be the case for the majority of domestic enterprises. Still, three caveats should be noted. First, in every country (even the least developed ones) there is problem solving and some degree of research, even if informal, to learn to use foreign technology efficiently. This may also be the case to adapt it to local circumstances, although it is possible that this type of adaptive innovation may require more formal R&D, depending upon the complexity of the technology and the amount of adaptation required for local conditions. Both of these require applied R&D, which may constitute experimental trialand error, for example. It is not necessarily in a formal manner or through a formal R&D department of an enterprise. It may take place in a very informal manner on a very small scale to address specific practical problems, particularly in the first case. It can therefore be difficult to detect in Government statistical surveys. Only carefully designed and administered surveys on innovation or enterprise behaviour would manage to capture relevant responses, especially from the micro and small formal and informal sector enterprises that would undertake the most basic applied R&D of this nature.

Even these firms do not have formal R&D departments, being mostly small and medium size enterprises (SMEs) and often family-owned and run, so measuring their R&D also requires some special effort to accurately identify and categorize activities as R&D or to measure it in terms of expenditure or units of labour (such as full time employment equivalents). The case of the family-owned enterprise Tiviski (box 3.3) in the dairy industry illustrates that even small family-owned enterprises in the country can and do invest in R&D. Their efforts being difficult to capture in formal statistics (these enterprises do not have R&D departments) they are not widely known and lead to the generalization that there is “no” R&D in the private sector.

**Box 3.3. Tiviski: An innovative Mauritanian family-run enterprise**

Tiviski is a 100 per cent family-owned company created in 1989, and managed by a Mauritanian of British origin (an engineer by training) along with her children. The production unit is located in a suburban area of Nouakchott and its line of production is milk and cheese processing. The enterprise faced major technological challenges that required applied R&D to solve. There was both product and process innovation behind the company’s business. There was also successful technology transfer from the scientists involved, which was facilitated by the engineering capabilities of the entrepreneur which provided a relatively high level of “absorptive capacity”.

Commercialization also required investment in the upgrading of equipment without which the new technology would not have led to the introduction of new milk (and cheese) products. The success of the enterprise was made possible through collaboration with foreign scientists and a local research institute as well as support by international financing agencies to overcome technological challenges, and a strategic deal with a large French TNC to help commercialize the product. Through the growth of the enterprise, imports of milk and other dairy products were replaced to a significant extent by local production supplied through both Tiviski and Toplait of the ASML Group. At the macroeconomic level, this type of import substitution benefits the country through the conservation of foreign exchange, which can be allocated to alternative uses.

Milk production and milk consumption are very seasonal in the harsh desert climate. Unfortunately, they follow opposite patterns. Milk is abundant when nobody is thirsty, except during the rainy season when it is particularly difficult to collect. To solve this problem, a new plant has been built, with self-funding and loans provided by PROPARCO, IFS and European Investment Bank, to produce long-shelf-life UHT milk. Milk is a perishable foodstuff, especially in severe heat, and requires UHT treatment in order to remain safe in Mauritania. It processes cow milk successfully, but camel milk becomes unstable at the high temperature applied during the UHT process. Research and testing is underway, in the hope that this hurdle can be overcome.

Tiviski used the research services of the National Institute of Livestock and Veterinary Research (CNERV) to help overcome technical challenges. They also benefited from both technical and commercial assistance from an important French dairy product TNC, Sodiaal, reaching a deal in April 2002 to commercialize milk under the French brand Candia, a well known milk brand. This is expected to allow the successful expansion of Tiviski's milk products throughout Mauritania, and perhaps eventually allow them to export in the sub-region.

Tiviski established a mini-dairy in 1989, beginning by processing camel's milk, which was the only fresh milk available in Nouakchott. They began processing cow's milk in 1990, and goat's milk was added in 1998. It was the first dairy in Africa – and the second in the world – to pasteurize camel milk. At the start of processing, the enterprise was limited to supplying Nouakchott because they lacked UHT technology that would make the milk storable and safe for transport and sale throughout the country. The rest of the country bought imported milk. Since mastering UHT technology and investing 3 million euros in 2001 to improve its processes and equipment, Tiviski began UHT milk production in 2002 and has expanded its market into other areas of the country. Through additional investment, the dairy today operates state-of-the-art stainless steel continuous pasteurization equipment and packages milk in gable-top cartons. Product quality is controlled in compliance with EU standards.

The business was very difficult to establish, owing to traditional prejudice against selling milk by livestock owners. But over the years, herders found that the regular income from milk sales raised their standard of living, enabled them to feed their livestock in dry periods, and became faithful suppliers. Nowadays thousands of camels, cows and goats are milked by hand, wherever they happen to be, and a network of pick-up vehicles carries the milk churns twice a day, over distances up to 90 km, to three collecting centres located in towns along the Senegal River. The dairy also provides veterinary care, vaccination and feed, on credit, as well as instruction on hygiene. Growing the business was also difficult because of domestic consumer preferences for imported goods. However, high-quality fresh dairy products gradually became accepted and preferred to imported sterilized milk, and sales gradually increased. In 2002, milk deliveries reached 20,000 litres a day, before a drought dealt a severe blow to the business.

Tiviski has also innovated by establishing production of camel cheese. Camel cheese is not easy to make, as camel milk does not curdle naturally. Besides, cheese making needs a cool, damp

climate. Still, with the help of an FAO technical cooperation programme, including the expertise of a French professor (who carried out the original research for FAO and discovered how to curdle camel milk), two types of cheese were “designed” with export to European markets in mind, cheese not being a tradition in Mauritania. European regulations do not cover camel cheese, so that new regulations must be drafted to cover imports of this product. The enterprise hopes that its camel cheese will soon be available for export.

Sources: Interview with the company; [www.tiviski.com](http://www.tiviski.com).

There has been a large amount expenditure on R&D by private foreign TNCs in Mauritania. Various foreign mining and oil and gas companies have been exploring for minerals, oil and gas, in Mauritania during the past decade. The cumulative expenditure to date on R&D by the various companies that have been active in exploration and development of these natural resources is unknown but is likely to be in the hundreds of millions of dollars. Extractive TNCs in Mauritania incur large costs in exploration in terms of geological mapping of exploration blocks for which they are licensed. For relatively deepwater offshore oil (or gas) exploration, which is dominant in Mauritania, the R&D costs are very high, as are actual development costs to begin extracting (or “producing”) oil.

It is important also to remember that the fact that there may be little private sector R&D effort in the country does not automatically mean that there is little innovation either. This is the case for three reasons. First, not all innovation is R&D-based or technology-based. Second, not all innovation relates to the creation of new products or new processes. Innovation can also take the form of organizational innovation (new organizational forms) or management innovation (new forms of management), for example. Third, there are different degrees or intensities of innovation. Innovation can conceptually be measured on a continuum from marginal improvements in existing products to groundbreaking innovations that have a major impact on an industry or society (for example, the design of the wheel, the steam engine or the microchip). This has led to standard categorizations of innovation into incremental (or minor) innovation and radical (or major) innovation. In a poor country with mostly micro and small enterprises that do not perform formal R&D, innovation may be relatively heavily non-R&D-based, non-technology based and more concentrated in low intensity, minor innovation. It is possible therefore that many enterprises, even in a poor country, may be innovative to some degree. However, even in LDCs such as Mauritania, there are enterprises that innovate in high-tech areas and establish export markets in developed countries, as the case of Top Technology of the ASML Group of companies (box 3.4) illustrates.

**Box 3.4. ASML Group and Top Technology: an established  
Mauritanian conglomerate with high-tech exports**

ASML Group is a Mauritanian conglomerate established in 1961. It is composed of nine companies : (a a cement company (Ciment de Mauritanie (CMSA)); (b an industrial concrete company (Béton de Mauritanie (BMSA)); (c) a construction and civil engineering company (Mauritanienne de Construction et d'Equipements (MCE)); (d) a door and window construction company (Top Window); (e) a trading company based in Las Palmas (Canaria Comercio Internacional (CCISA)); (f) an engineering and consulting company (Béta conseils); (f) a maritime consignment and transit company (Consimar); (g) an information technology company (Top Technology); and (h) a dairy products company (Toplait).

The group was established directly following independence with the main business of importation of products for onward sale in Mauritania. Today, its main business is construction, and four companies in the group are active in this area. It has also developed strong capabilities in other activities, notably in IT and in dairy products. The group has invested heavily in upgrading its skills and technology to meeting international quality standards, and two of the group companies have attained ISO certifications awarded by BVQI (Bureau Veritas Qualite Internationale). CME (established in 1979) has attained ISO 9002 and Top Technology (established in 1990) ISO 9001/2000. These capabilities are based upon the development of specialized skills that have been leveraged through collaboration and strategic partnerships with foreign enterprises, which has provided improved market access and enlarged business opportunities in export markets. In the case of Ciment de Mauritanie, Cemex (Cementos Mexicanos) of Mexico owns a 10 per cent strategic interest in the company (and through CME a 50 per cent interest in BMSA). The group is also one of a small number of companies known to have established links with local research centres. Top Lait (which produces milk products), like Tiviski (see box 3.3), has used the National Institute of Livestock and Veterinary Research (CNERV) to conduct applied research on their behalf.

Within the Group, one of the most innovative companies is Top Technology. It custom designs telecoms and IT software products, and is reportedly the only enterprise in Mauritania to export software products. It originally developed its specialized IT software skills by sending two staff to the United States for training in software engineering. Efforts to build, maintain and upgrade technological capabilities have reportedly all been internally driven by the group itself, without support from Government or the public sector (in the form of business development services for example, which are common in many developing countries but lacking in Mauritania). The conglomerate form of business operation may assist the group in financing group operations, given the ability to cross finance activities through profitable group activities among the various group companies. The company was the first private enterprise in Mauritania to be certified ISO 9001/2000. It started international operations through partnership agreements with international companies active in the field of computers, networking and telecommunications equipment.

Top Technology has diversified its activities, mainly in ICT, by producing software such as a billing system, called ITTISAL, which was fully developed by its Mauritanian technical staff. The ITTISAL software is a billing solution for internet telephony service providers, designed and developed to satisfy billing needs using web-based on line tools for management and reporting. They ensure the development/personalization, sale, customer training, maintenance and technical guarantee of the product. The technical team, composed of three permanent researchers, undertakes continuous collaboration on international projects through strategic partnerships with international companies such as that with Net.com in the United States, which regularly recommends ITTISAL to its customers. This product has been marketed in the United States since 2001 and is now in use in various countries, including Algeria, Bahrain, France, Jordan, Kuwait, Senegal and Mauritania.

*Sources:* Interviews with company; company document "ASML Group"; information from company's internet site [www.toptechnology.mr](http://www.toptechnology.mr).

### **3.4 Access to international technology (inward international technology transfer)**

The Review attempts to examine the effectiveness of Mauritania in using the available channels of access to foreign technologies and the policies implemented to

promote technology transfer. There exist a multitude of channels through which technology can be transferred between countries. Most of these channels involve some aspect of openness to, and linkages with, people, enterprises and organizations (research institutes, universities and international organizations) in foreign countries. The channels of technology transfer may for example include:

- The entry and operation of foreign enterprises in the country, many of them TNCs entering through FDI projects or non-equity, non-FDI arrangements;
- Joint ventures or strategic partnerships with foreign enterprises;
- The movement of staff between foreign enterprises using foreign technology and domestic ones;
- Domestic firms developing strong linkages with TNCs and other foreign enterprises as domestic suppliers within Mauritania;
- Domestic enterprises investing in (or buying) foreign enterprises that have specialized technology and experience through mergers and acquisitions (M&As);
- Imports of machinery, equipment and other capital goods that contain embodied technology;
- Studying (for example, reverse engineering) imported products to learn how “embedded” foreign technology works and imitating their production;
- Licensing agreements between domestic enterprises and foreign owners of technologies and producers of goods that embody technology;
- Technical assistance projects with international agencies and donor countries that include foreign experts working in the country;
- Members of diaspora abroad returning home and bringing foreign technology;
- NGOs bringing in foreign technology or providing people with specialized knowledge;
- Local agents undertaking joint research or production projects with foreign enterprises and organizations;
- The inward migration of foreigners with specialized knowledge and skills;
- Temporary study and training abroad of residents in foreign schools, research or technical institutes;
- Hiring of foreign managers to work in domestic enterprises or local subsidiaries of TNCs;
- Hiring of foreign consultants with specialized knowledge and skills;
- Internships by local workers or students with foreign enterprises;
- Attending seminars and conferences abroad or holding seminars or conferences locally and inviting foreign experts; and
- Accessing technology available through technical publications, journals or patent databases, which can be greatly facilitated by adequate computer and internet connectivity.

**Policies on FDI and TNC operations**<sup>18</sup> - As part of the reform programmes over the past two decades, FDI policies have been liberalized and the country is today very open to FDI in almost all industries. Indeed, the Government has in recent years encouraged FDI in several areas, including mining, oil and gas, fisheries, telecoms and tourism. Not all foreign companies operating in Mauritania are necessarily TNCs, although the largest players are generally TNCs. It should be noted that TNCs and foreign companies operate in Mauritania not only through investing locally (i.e. through FDI in Mauritania), but also through activities that do not involve any equity investment (i.e. non-FDI modes of entry). This is notably the case of many foreign fishing companies that are authorized to fish in Mauritanian territorial waters through fishing agreements signed with foreign countries. These ships have very limited contact with Mauritania and conduct their fishing operations strictly offshore. In many cases, foreign TNCs enter through FDI projects. So TNC entry, foreign enterprise entry and FDI provide different measures of the scope of operations of foreign enterprises in the country. The paucity of reliable data on all three presents a challenge in producing an analysis of FDI and TNC operations in the country. It is the incidence and nature of foreign enterprise operations that are most relevant for the potential transfer of technology, not the size of FDI flows, which is also to at least some extent a reflection of TNCs' preferences regarding financing structures for their investment projects. FDI inflows into Mauritania, TNC operations there and inflows of foreign financing related to TNC projects are not equivalent.

New regulations on FDI were established in 2002 (law 2002-03 of 20 January 2002), replacing the investment code of 23 January 1989, and the Government is in the process of further revising these laws. The 2002 law covers most but not all industries, with mining, oil, banking and insurance being subject to sector-specific regulations. The Government is in the process of designing a new investment code for FDI, and has expressed the intention to improve the investment climate in Mauritania as part of the strategy to develop the private sector as the main engine of growth (UNCTAD, 2008b). This commitment is clearly evident in the establishment of the General Delegation for the Promotion of Private Investment (DGPIIP) in April 2007. The Government is also a signatory of various international agreements on investment, and as a WTO member is subject to the GATS, TRIMS and TRIPS agreements.

Mauritania offers several guarantees to foreign investors and these include availability of hard currency to import all goods and services needed for operating the enterprise and for repaying loans contracted; freedom to transfer foreign capital; ability to transfer professional income of foreign employees; protecting vested interests and equal treatment of Mauritanian and foreign individuals and legal entities. There are no legal or policy restrictions on converting or transferring funds associated with a foreign investment project. In terms of investment protection, Mauritania has also instituted measures to address investment disputes as well as respect property rights. Mauritania is a signatory to the procedures of arbitration through World Bank Group's Convention on the Settlement of Disagreements Related to Investments between States and citizens of other States and the 1958 New York Convention on the Recognition and Enforcement of Foreign Arbitral Awards. Mauritania is a member of the Multilateral Investment Guarantee Agency (UNCTAD, 2008d).

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<sup>18</sup> For a comprehensive analysis of the regulatory framework for FDI, FDI trends and issues related to TNC operations in Mauritania, see UNCTAD (2008b).

FDI inflows have for most of Mauritania's recent history been very small. Since 2000, however, there has been a marked rise in FDI inflows due to an acceleration in activity under the privatization programme at the end of the 1990s and to increased TNC entry in mineral, oil and gas exploration and production in recent years. The latter has resulted in part from the dramatic rise in international commodity prices (in particular oil but also gas and various other minerals) since 2003, and the discovery of oil and gas deposits offshore in 2003 and the need for increased investment to complete exploration activities and begin oil production. TNCs in various other industries have also begun investing in the country in response to continued privatization, the promise of faster economic growth with the discovery of oil and an increase in the presence of other TNCs and in business and tourist visitors. As a result, in relation to the size of the economy (GDP) and the small population, FDI inflows became relatively large compared to neighbouring countries and to LDCs as a group (UNCTAD, 2008b). FDI inflows jumped to almost \$400 million in 2004 and peaked at over \$800 million in 2005 (see table 2.1 in chapter 2), the bulk of this related to oil exploration and production (the latter started in 2006). The dominance of oil FDI in the total immediately raises a warning over the natural limits to potential for positive externalities (spillovers) in terms of technology transfer and production linkages given the enclave nature and the low employment and high capital intensity of the industry.

Mauritania's openness to FDI and the entry and operation of TNCs have in many respects been beneficial, including with respect to increasing gross investment, GDP, Government revenues, local employment and exports. For example, oil production began in 2006 and is estimated to have added about 5 per cent to GDP growth in that year, an enormous growth impact. In principle there could also be both direct and indirect transfers of knowledge and technology (business management and project management skills, marketing skills, production knowledge, technical skills and equipment (with "embodied technology") to Mauritania. There should be some degree of direct intra-firm technology transfer via TNCs to the local TNC affiliate. There may also be indirect technology transfer within Mauritania to domestic firms through, for example, spillovers from the mobility of local staff between these TNCs local operations and domestic enterprises, or through relations with domestic supplier firms. Clearly, there has been knowledge, skill and technology transfer to local TNC affiliates. In oil and mining in particular, it would not be possible to run a successful exploration or production project without reasonably advanced technology, the requisite specialized skills and knowledge of the appropriate equipment and how to use it.

The bulk of TNC activity in the country is in mining and oil, industries known for their relatively limited transfers of technology and learning to a host country, due to the relatively specialized nature of the knowledge and skills involved and their enclave nature. As earlier discussed, oil and mineral TNCs were responsible for imports of equipment related to mineral and oil exploration and production large enough to cause major balance-of-payments effects in 2005 and 2006. They also brought in personnel with very specialized knowledge and skills. However, the degree to which spillovers from FDI have diffused this technology more widely among enterprises in Mauritania is very difficult to measure. The literature on FDI suggests that successful technology transfer requires adequate absorptive capacity on the part of domestic firms and their employees. In Mauritania, this has for many enterprises (and staff) posed a challenge, and has probably limited the development of production and supply linkages between TNCs and local enterprises that could promote technology transfer through either exposure to their operations, imitation, quality standards imposed by them or from direct support provided to help them meet these quality standards.

Domestic firms in the country are generally not integrated into the international production networks, or the regional or global value chains, of TNCs operating there. This limits the extent of technology transfers that could take place.

Technology absorption and diffusion locally would have occurred to the extent that local people and enterprises - technicians, engineers and enterprises - were involved in the oil exploration and production activities and ancillary support activities. These are the linkages that could be created and act as channels to transfer technology. From discussions and the analysis in the oil study in this Review, it is clear that some enterprises did establish linkages with these TNCs, but how many were domestic enterprises is not clear. The main logistics services companies used in oil production, Shenker and SOGECO, are both subsidiaries of TNCs, but are mostly staffed by Mauritians. The offshore equipment suppliers are all foreign enterprises, given that these are specialized services with heavy equipment that cannot be supplied by Mauritanian enterprises. In terms of supplier linkages creating technology transfers this appears to have been very limited in nature. However, in terms of local staff of suppliers experiencing technology transfers, this is likely to have taken place to some extent. In discussions at least one TNC noted that a small percentage of local staff left after a year or two and attempted to apply the knowledge and skills learned at the TNC to establish their own business. It was not possible to verify whether this had led to the establishment of successful domestic enterprises or to what extent technology transfer had actually taken place. More targeted research aimed at answering these specific questions would be needed to provide a satisfactory answer to these issues.

In non-mineral industries, there have probably been larger spillovers given the larger potential for building linkages with TNCs and the coexistence of foreign and locally-owned enterprises that allows for mobility of people among the two and demonstration effects whereby local enterprises observe and adopt more efficient practices introduced by foreign firms. In addition to oil, gas and mining, TNCs have entered the telecoms, banking, hotels, logistics and agro-food industries (UNCTAD, 2008b). Policies aimed at promoting the development of supplier relations and other linkages with TNCs where opportunities for mutually beneficial relations exist could be useful, for example, in providing information on potential opportunities through information services combined with business development services to assist domestic enterprises exploit these opportunities.

**Trade policies** - Trade is another major channel through which technology transfer can take place. In Mauritania, trade policy, like FDI policy, has been extensively liberalized through its various economic reform programmes. Trade reforms have resulted in the reduction of both export and import tariff and non-tariff barriers, and the country has relatively few barriers to trade (WTO, 2002). The trade regime is therefore very open in Mauritania.<sup>19</sup> The country joined the WTO in May 1995 becoming thereby subject to its trade rules. They have also joined the Arab Maghreb Union with Tunisia, Algeria, the Libyan Arab Jamahiriya and Morocco, which established a free trade zone by removing tariff and non-tariff obstacles among the member countries. The movement of goods throughout this zone is thus duty free, while imports from outside pay a common tariff, which makes this community a Customs Union.<sup>20</sup> Other trade agreements include the ACP-EC Partnership Agreement (Cotonou Agreement), bilateral trade agreements with Algeria, Egypt, Gambia, Mali,

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<sup>19</sup> There are few restrictions on importing foreign products, and in discussions it was actually reported that regulation of imports in terms of quality standards on imports were actually inadequate, leading to an inflow of products of substandard quality but at very cheap prices.

<sup>20</sup> Union de Maghreb Arabe, <http://www.maghrebarabe.org/index.htm>.

Morocco, Senegal and Tunisia as well as the Generalized System of Preferences (GSP) of industrialized countries such as Japan and the United States (WTO, 2002). They are also included in the “everything but arms” programme and the AGOA programme, although this Review does not attempt to measure to what extent the country actually gains from such preferential arrangements.

Nevertheless, while trade liberalization has created a more competitive environment in Mauritania, the weakness of supply capacity in Mauritania resulting from the deficiencies in enterprises and the operating environment has mitigated the positive impact of trade liberalization. It is expensive to export from Mauritania – even for TNCs – due to deficient transport infrastructure combined with an improved but still reportedly slow customs bureaucracy, but domestic enterprises face additional obstacles that can be overcome by TNCs, as noted elsewhere. Smaller firms face great obstacles. The few larger, better-funded family groups are more easily able to operate successful businesses. But in general there is a major question regarding the ability of most domestic enterprises to compete successfully with imported products as well as with TNCs entering the country and operating in similar markets and activities. It is much easier to expand imports than to improve export performance given weak domestic supply capacity.

Under recent reforms, the Ministry of Trade and Industry (MTI) was created (under Decree 085/2007 of 17 June 2007) and entrusted with designing and implementing the country’s industrial policies by assessing the investment opportunities in the country in order to develop manufacturing activities favouring economic growth and job creation. MTI has three departments which are in charge of industrial development, standardization and the promotion of quality and the promotion of foreign trade respectively.

The Department for the Promotion of Foreign Trade is mainly entrusted with four major tasks: designing incentives for the promotion of exports to the regional market (mainly the promotion of economies of scale within enterprises); training and support to public and private producers; monitoring and standards notification to the WTO; and the negotiation and follow-up to implementation of Trade Agreements. MTI therefore has a role in assisting enterprises in exporting, but reportedly there is no strategy for doing this as yet. The remains, therefore, a lack of State support to enterprises active in export or potential export activities.

As many enterprises have rudimentary STI capabilities, they are less likely to be capable of absorbing (that is, successfully mastering) foreign technologies, particularly without access to the tacit knowledge that may need to accompany technology embodied in physical machinery imports. These tacit elements can limit the ability of many enterprises to effectively absorb and diffuse these technologies without servicing contracts that provide for training. For simple cases of equipment imports such as personal computers, many individuals and enterprises simply do not absorb the technology very effectively. In Mauritania, based upon discussions, it seems clear that for most users of computers, even in enterprises, only the simplest elements of the technology is used – standard word processing software, for example – and they are likely to be used in a relatively inefficient manner. This greatly reduces the impact of foreign technology transfer on local productivity. As noted earlier, imports of manufactured products have risen dramatically since oil was discovered in Mauritania and additional exploration and actual production have progressed. There was a significant rise in machinery equipment related to oil and mineral exploration in 2004 and 2005. As noted in chapter 2, machinery and equipment imports apart from those related to

oil, mining and motor vehicles have been low, reflecting the small manufacturing base in the country and limited import ability due to continuing foreign exchange scarcity.

**Diaspora linkages** - As in LDCs more generally, Mauritania is subject to a brain drain through the emigration abroad of much of its skilled human capital, and over time, a significant skilled diaspora abroad has developed. This has been facilitated by the dependence on universities abroad for university level training, and many Mauritians remain abroad or return for a short time before emigrating. This phenomenon reflects fundamental economic conditions in the country. In particular, slow economic expansion and job growth provide slow expansion in skilled employment opportunities, and relatively low wage rates compared to developed countries or more developed developing countries, encourage many skilled people to seek employment abroad and students studying abroad to remain there upon graduation (as noted in Government of the Islamic Republic of Mauritania, 2005a). This is very costly for the country in terms of the return on investment made in education and skill development.

It also offers an opportunity to create “brain circulation” (UNCTAD, 2007a) if effective linkages can be established with this diaspora, which can act as a channel for knowledge and technology transfer. Unfortunately, to date such linkages have not been established, although an effort was made to initiate contact with researchers abroad by organizing a meeting in 2002, as noted elsewhere. No follow-up to this meeting has taken place, reportedly due to a lack of financing (Government of the Islamic Republic of Mauritania, 2005a: 16). Reducing the brain drain and finding ways to leverage the diaspora are challenges faced by many LDCs and most of Africa. Based on other countries experience in this respect, it may be easier to leverage them if economic activity begins to expand rapidly and enterprises, universities, research institutes and the public sector are able to improve working conditions and offer higher wages to skilled people. Until then, innovative schemes may be required to attract them back or create useful linkages while they are abroad. One possibility that could be exploited at little cost is promoting the use of the diaspora of researchers as a means of scanning for foreign technologies that could be useful in some way in Mauritania. This function could also be pursued by consulates in foreign countries, but consulates may be less directly exposed to technologies than researchers working abroad.

### 3.5 Summary

As indicated earlier in this chapter, the R&D system is often the focus for STI policy. However, a focus on research in isolation presents several risks. First, a focus purely on research is likely to encourage a very traditional, linear view of innovation, which has itself given way to the more realistic and useful systems view of innovation. Second, related to this, looking at research in isolation from innovation raises the distinct risk of missing the critical issue of linkages with clients who could benefit from the research in the public and private sector, and commercialization of the research that will help generate increased wealth and show that the research is useful and has a positive impact on the country. These linkages are needed to ensure that research is applied to solving real problems such as improving production methods or meeting social or environmental challenges. This would increase support for research, which currently appears to have little real support either at the highest levels of Government or in society more generally.

In addition, prioritization is likely to be key in a context of scarce financing opportunities in which research support must be carefully targeted to avoid spreading resources too thinly to allow effective R&D in any one area. Given the stringent financing options and the huge challenges (in productivity and economic development, environment, health etc) in Mauritania, it is important that public research be coordinated for the purposes of ensuring a targeted approach based upon strategic priorities. These should aim at innovation to either provide solutions to pressing socio-economic and environmental challenges (such as desertification, for example), to overcome challenges faced by industry (such as inexpensive and workable energy sources or developing seeds for crops specially adapted for arid climates, for example) or to adapt foreign technologies for effective use in Mauritania. This research should help support technological upgrading to absorb these technologies in close collaboration with private and public sector users of the technologies.

Nevertheless, purely in terms of research, there have been some institutional developments that represent progress upon the previous ones in which there was no clear attempt to ensure coordination of public research activities. It is not clear to what extent the institutional effort to ensure coordination has led to increased effectiveness of research. Discussions with various stakeholders indicated that research activities remain uncoordinated and are not subject to strategic planning and prioritization. This is a natural tendency for any country that does not develop mechanisms to counter it. In Mauritania, as in any country, how to achieve this with regard to myriad public research institutes with different areas of focus is an important question. Effective strategic planning, prioritization, coordination and monitoring require an appropriate institutional structure and the human and financial resources needed to carry out this role. Ideally, these roles should be undertaken within the context of a broader STI strategy at the national level that would help in establishing priorities.

The issue of training is closely related to that of research. Training is required for people who have passed through the higher education system as well as those who have not. It may be necessary for specialized researchers who have attained high levels of formal education but lack a strong grounding in practical aspects of research. This is likely to be especially important in Mauritania where the higher education system is reported to be relatively heavy in emphasis on theoretical rather than practical aspects in technical subjects. The education system, and the bulk of the research of the University of Nouakchott, focus on theory rather than applied science. So the type of research is a key issue, as are the amount of research and the specific disciplines in which it takes place.

There needs to be an effort by policymakers to reconsider the appropriate roles of the university, how it operates, the public resources allocated to it and other potential sources of financing. It currently appears to play an insignificant role as a center of innovation in the country. Finding ways to make it attractive for enterprises to fund some of the activities of the university is another issue to consider. Joint projects aimed at practical problem-solving are an area of potential to be considered. Private enterprises must see clear benefits to them from providing any financing. Using a portion of the revenues from mining and oil companies active in Mauritania to finance technical training programmes designed for these industries and the Government ministries that regulate them – whether this training could be through the university or a more specialized technical institute – is another option. Major reform may be needed to recreate the institution as one that can operate more at the centre of a dynamic knowledge system, more along the lines outlined, for example, in United Nations (2005).

Innovation in the manner of organizing and delivering higher education services, in particular the university, is highly needed in Mauritania.

Mauritania is today very open to most channels of international technology transfer, having reformed trade and FDI policies in particular. There have been many exchanges related to the inward and outward movement of people that bring inward flows of technology transfer through various channels noted above. Government policies allow these types of exchanges, and have, through their ICT policies aimed at expanding the availability of computers and internet, also helped facilitate access to foreign technology. However, there are no direct policies specifically targeted at encouraging international transfer of technology into the country or official body to promote such transfers. As noted in Government of the Islamic Republic of Mauritania (2005), there is no known direct and active support to domestic enterprises in searching for, identifying or accessing foreign technologies. This places the responsibility on enterprises to undertake these activities and arrange for any assistance in doing so by themselves. Ideally, there would be Government support of some kind to assist enterprises in searching for and identifying appropriate technologies that could increase productivity, at least for innovative enterprises willing to make major investments to improve STI capabilities and improve their technology through international or even domestic technology transfer. Support may be especially warranted in cases where simple and cheap technologies exist and could make a large difference to improving production methods of many small subsistence producers. The Department of Industrial Development of the Ministry of Trade and Industry, for example, could be designated as a focal point for promoting inward international technology transfer. But it is possible that the skills and knowledge necessary to supply such services may not be readily available. There are also likely to be financing constraints in this respect.

Sector policies and financial systems to support the development of indigenous STI capabilities in enterprises form part of the “enabling environment” for national systems of innovation. It is these, and other elements and conditions within this enabling environment, that are discussed in the following chapter.

## CHAPTER 4 - STI FRAMEWORK CONDITIONS AND INFRASTRUCTURE

This chapter assesses the general framework conditions and infrastructure (both physical and institutional) in which technological development takes place in Mauritania. Here, the key aspects are divided into four categories: the enabling conditions for enterprise development (in general), regulatory regimes (including Intellectual Property Rights), physical infrastructure, and “human capital” (which includes basic education and skills development in the general population).

### 4.1 Enabling conditions for enterprise development

A central part of the various economic reform programmes has been reduced Government participation in production through privatization of State-owned enterprises (SOEs). The privatization programme was extensive, covering many important industries such as fisheries, manufacturing, agriculture, construction, insurance, banking, transport, telecoms, energy and opening other industries such as mining to private enterprises. The State industrial and mining company SNIM (Société Nationale Industrielle et Minière), the State electricity company SOMELEC (Société Mauritanienne d'Électricité), the State water distribution company SNDE (Société Nationale de l'Eau) and the national airline Air Mauritanie are four of the few remaining SOEs.<sup>21</sup>

The withdrawal of the State from production has meant the need to support the development of the domestic private sector to take its place. As noted in a recent IMF review of Mauritania (IMF, 2007b: 27), private sector development is considered essential to growth and promoting employment. A strategy for the development of the private sector is reportedly being prepared and will in particular address the issues of access to bank financing, basic infrastructure development, improvement in the business climate, increased foreign direct investment, implementation of the commercial code, and adoption of a new investment code. The Government is therefore aware of major constraints to private sector development and actively engaged in formulating a strategy to address them. It is notable, however, that the development of improved enterprise capabilities does not feature as a priority issue. Other elements noted as priority areas are discussed in this chapter.

**The investment climate** - In poor developing countries with high poverty rates, a key element in reducing poverty is to create rapid economic growth that is employment generating. UNCTAD's Least Developed Countries Report 2006 (UNCTAD, 2006) argues that building productive capacities is the basis for LDCs to make this possible. To achieve this, high rates of domestic investment (both public and private) are required. There is reasonably wide agreement that the investment climate in a country is a major determinant of domestic savings and investment patterns. There is less agreement on what exactly is meant by “investment climate”, but in essence it is the ability of investors to carry out investment projects and operate profitably with a medium or long term planning horizon – which depends upon various elements, including in particular the legal and regulatory framework, the degree

<sup>21</sup> There are plans to reform the SOEs to improve their service delivery including a restructuring strategy for SOMELEC to be designed in 2008 and a strategy to disinvest from Air Mauritanie (IMF, 2007b: 34).

of political, social and macroeconomic stability or instability and the rule of law and enforcement of contracts in addition to the availability of the factors of production needed to carry out business activities (access to human, physical and financial capital, land and technology).

In terms of the overall business environment, Mauritania ranks similarly to Mali and Senegal on the ease of doing business index, but much lower than other North African comparators and lower still compared to some other selected African comparators such as Ghana, Kenya and South Africa (see table 4.1). Its ranking has also fallen in recent years, from 146 in 2005 to 157 in 2007. Its business regulatory environment rating by the World Bank is similar to that of comparators for which data were available for 2006.

The main constraints cited in World Bank (2007) as major or severe constraints by the largest percentage of enterprises in manufacturing, trade and other activities and for microenterprises (i.e. the informal sector) in particular include access to affordable finance, electricity, competition practices of the informal sector, regulations related to customs and foreign trade, inadequately skilled workers, tax rates, administration of fiscal legislation and access to land. Some enterprises (at least a fifth of them in any category) also see transport and corruption as major constraints. The rankings of what constitute the most severe constraints vary by category, but access to affordable finance is consistently cited as one of the most severe constraints. Macroeconomic and political instability are relatively low in the list of constraints. These confirm the major finance, infrastructure (electricity and transport) and skills impediments that are common to many LDCs, but indicate that regulatory issues related to customs and trade, and tax and fiscal issues also continue to present major obstacles for many enterprises.

A comparison with several other developing countries for manufacturing enterprises is provided in the report. The comparator countries tend to cite similar issues as representing major constraints. It is remarkable, however, that access to affordable finance is reported by an even larger percentage of firms as a major or severe constraint in Morocco and Brazil – both middle income countries with more developed manufacturing sectors and STI capacities than Mauritania – as well as Senegal and Mali, close neighbours with similar income levels and economic challenges. Electricity is far more of a problem for manufacturing enterprises in Mauritania than in all other comparators. Inadequately trained workers represents a significantly larger problem in Mauritania than in its most closely matched comparators, Mali, Senegal and Morocco, indicating that in terms of its skills base it lags even its neighbours that are experiencing similar challenges in STI capabilities.

Corruption is less frequently cited as a problem<sup>22</sup>. Finally, the constraint from informal sector competition practices, while serious in Mauritania, is even more frequently a major problem in its neighbours Senegal, Mali and Morocco. The most severe difficulties for enterprises with the investment climate therefore include finance, infrastructure (electricity and transport), informal sector anticompetitive practices, inadequate skills, and regulatory issues related to customs and trade and tax and fiscal issues.

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<sup>22</sup> Although the World Bank cautions that the problem is nevertheless costly for enterprises, and corruption was noted by some stakeholders in discussions as an important obstacle to economic, social and political progress in the country.

Table 4.1. Doing business in Mauritania and selected other countries, 2004–2007

		Mauritania	Mali	Senegal	Tunisia	Algeria	Morocco	South Africa	Ghana	Kenya	Malaysia
Start-up procedures to register a business (number)	2004	11	13	10	10	14	6	9	12	12	9
	2005	11	13	10	10	14	6	9	12	13	9
	2006	11	13	10	10	14	6	9	12	13	9
	2007	11	11	10	10	14	6	9	11	12	9
Time required to start a business (days)	2004	82	42	58	11	24	12	38	85	47	30
	2005	82	42	58	11	24	12	35	81	54	30
	2006	82	42	58	11	24	12	35	81	54	30
	2007	65	26	58	11	24	12	31	42	44	24
Cost of business start-up procedures (% GNI per capita)	2004	140.8	187.4	112.9	11.1	30.1	13.7	9.7	65.1	53.4	25.1
	2005	143.6	190.7	108.7	10	12.4	13.4	8.6	58.6	48.2	20.9
	2006	121.6	201.9	112.6	9.3	13.4	12.7	6.9	49.6	46.3	19.7
	2007	56.2	132.1	107	8.3	13.2	11.5	7.1	41.4	46.1	18.1
Time to resolve insolvency (years)	2004	8	3.6	3	1.3	2.5	1.8	2	1.9	4.5	2.3
	2005	8	3.6	3	1.3	3.5	1.8	2	1.9	4.5	2.3
	2006	8	3.6	3	1.3	2.5	1.8	2	1.9	4.5	2.3
	2007	8	3.6	3	1.3	2.5	1.8	2	1.9	4.5	2.3
Procedures to enforce a contract (number)	2004	40	28	33	21	49	42	26	29	25	31
	2005	40	28	33	21	49	42	26	29	25	31
	2006	40	28	33	21	49	42	26	29	25	31
	2007	46	39	44	39	47	40	30	36	44	30
CPIA business regulatory environment rating (1=low to 6=high)	2004	..	..	..	..	..	..	..	..	..	..
	2005	3.5	3.5	3.5	..	..	..	..	4	4	..
	2006	3.5	3.5	3.5	..	..	..	..	4	4	..
	2007	..	..	..	..	..	..	..	..	..	..
Ease of doing business index (1=most business-friendly regulations)	2004	..	..	..	..	..	..	..	..	..	..
	2005	146	165	152	77	123	117	28	102	80	25
	2006	148	155	146	80	116	115	29	94	83	25
	2007	157	158	162	88	125	129	35	87	72	24
Time required to obtain an operating license (days)	2004	..	..	..	..	..	4.94	..	..	..	..
	2005	..	..	..	..	..	..	..	..	..	..
	2006	10.69	..	..	..	..	..	..	..	..	..
	2007	..	..	..	..	..	..	..	6.36	..	..
Credit information availability index (0=less info to 6=more info)	2004	..	..	..	..	..	..	..	..	..	..
	2005	..	..	..	..	..	..	..	..	..	..
	2006	1	1	1	3	2	1	5	0	2	6
	2007	1	1	1	4	2	1	6	0	4	6

Source: World Bank WDI Online Database (April 2008).

Obstacles related to market structure and anticompetitive practices of different enterprises were also noted as a major issue in discussions with various stakeholders. In addition to the issue of informal sector enterprises generally not being subject to Government regulation and taxation, a highly monopolistic or oligopolistic market structure in the formal private sector in many activities was also mentioned. The reported persistence of monopolistic and monopsonistic practices (World Bank, 2006: 59) may provide unfair competitive advantages to firms possessing monopoly power and create barriers to the entry of new enterprises. The World Bank (2006) notes that trading monopolies effectively discriminate against domestic producers in favour of imported products, in dairy products for example. The competitive disadvantages of some enterprises are reportedly accentuated by these practices which may act as a disincentive to starting an enterprise or to private investment more widely.

Government has taken actions to stimulate a more competitive market structure through its extensive privatization programme that has introduced private ownership of most productive activities, but this has not been adequate to create a competitive domestic market structure. There is no specific law on competition (antitrust) in Mauritania, but there are competition regulations in the commercial code of 22 April 1991 (ordinance 91-09). There is also a Multisectoral Regulatory Authority, created in 2001 (under law 2001-18) to oversee the privatization of selected utilities (water, electricity, telecoms and the post office) and to regulate them, but it appears to have very limited competition powers. The MRA was originally formed in 1999 as the telecoms regulatory authority but received an expanded mandate in 2001 to cover other utilities as well. Monopolistic and monopsonistic practices should fall under the purview of regulatory authorities, who should ensure that such practices do not discriminate against the entry of new enterprises, or against local producers.

Intensive trade and foreign investment liberalization, and the entry of TNCs, have greatly increased domestic competition. However, the ability of domestic enterprises to respond to the different incentive structure created by increased competition is far from uniform, and a large number of domestic enterprises that operate in import-competing activities may experience difficulty in generating sufficient revenues to remain in operation. The small group of family-owned conglomerates is likely to be in a much stronger competitive position to allow a successful adjustment to more intense external competition. Informal sector enterprises may have advantages resulting from the ability to escape Government taxation and other regulations, while also facing disadvantages related to limited access to financing and very weak STI capabilities, among others. The implication is a difficult environment for formal sector SMEs that face competition from imports and foreign enterprises, well established domestic conglomerates and informal sector enterprises that face less regulation and tax charges.

The burden on enterprises from taxation is a difficult issue because it may reflect a very narrow tax base that reflects the low income level of households, but may also imply weakness in the ability of Government to collect taxes that are due from other sources. The Government has in recent years undertaken tax reforms to reduce tax rates, but the issue needs further consideration to see whether reform to broaden the tax base is appropriate. On labour market regulation, the obstacles may relate to the difficulty in implementing regulations in place under the labour code of 2004, but there should be investigation to establish the source of the problem and to identify possible solutions. It is possible that given few alternative sources of productive employment, workers attempt to raise the cost to an

enterprise of terminating their employment. The development in the medium and longer term of a more dynamic and entrepreneurial private sector characterized by the creation of start-ups on a continual basis would help to provide alternative sources of employment and allow easier termination of employment at lower social and economic cost to workers concerned. It appears that bureaucratic delays are partly responsible, which call for direct action to reduce these delays.

**The financial system and financing of enterprises** - As noted in the previous section, one of the most severe constraints to starting, operating and growing an enterprise in Mauritania is the widespread lack of access to reasonably priced finance of reasonable maturity. Interest rates have been high for many years, with real interest rates of well over 10 per cent for most of the period 1995–2003 (see table 2.1). Since 2004 real interest rates have fallen significantly, which may have helped to reduce the severity of the financing constraints faced by enterprises. Loan maturities, however, have remained very short term at less than one year, which is adequate for short-term trading activities but not for business investment. Severe financing constraints are in part a symptom of the country's early stage of financial sector development, itself largely a reflection of the early stage of economic development of the country and the incomplete legal and institutional framework for a developed financial system that accentuate information problems and raise the degree of uncertainty in banking activities – both of which are inherent challenges in all financial systems. The high price of credit means that only projects with very high projected rates of return will be financed through the formal financial system, and more risky ventures with hard to forecast future cash flows will be especially difficult to finance. A second cause of high lending rates (and high spreads over deposit rates) is a low level of competition in the banking system. The sources of finance for entrepreneurs are therefore mostly informal sources (including personal and family savings) or retained profits for enterprises already in business. Only larger, more profitable enterprises and those that are part of a business group that includes a bank can easily access business financing. Early stage financing and venture capital have not yet been developed in the country.

In Mauritania, the banking system is dominated by a small group of commercial banks that are part of large family-owned business groups. This market structure presents a challenge to financial market development and fulfilling the efficient allocation of credit that is a key to the proper functioning of a market economy, and its ability to create economic growth and prosperity. It is perhaps also in part due to cultural and religious attitudes and practices in an Islamic State and resistance to the charging of interest on loans and taking of interest on deposits. These may help to sustain a highly cash-based society with extensive use of informal systems of payment.

The limited penetration of banking and other financial services is likely also to result from the relatively high risk level of microenterprises and SMEs and the difficulty of providing services to extremely low income families. This may be accentuated by the lack of reliable sources of credit information (there are no private credit bureaus) or similar institutions that would facilitate access to credit history data. As a result, the banking system does not function effectively as a conduit for excess savings by depositors into loans to individuals and enterprises in need of financing. This, when combined with the country's low income level and what is likely to be a generally low level of profitability among most enterprises (judging by generally low productivity levels among micro- and small enterprises), leads to very low savings and investment rates as well as a lack of formal sector finance for most enterprises.

In addition, commercial bank interest rates are high in nominal and real (inflation adjusted) terms which makes access to finance expensive for those customers able to obtain access. This is due in part to moderately high rates of inflation in recent years, but also to a low degree of competition in the banking system.

As a result, a very high percentage of enterprises find access to reasonably priced finance acts as a major constraint to starting or running a business, as indicated in the World Bank Investment Climate Assessment discussed earlier (World Bank, 2007). Only a small number of family-owned domestic business groups, conglomerates in nature, have ready access to finance at reasonable cost due to their links with specific banks, which leads to a competitive disadvantage for most enterprises. This problem was confirmed in discussions with various stakeholders in the country. The constraints on access to finance is critical because microfinance programmes, which exist and have been active for at least the past decade, have not filled, and cannot fill, the void left by the commercial banks and the wider formal financial system.

**Commercial banking system** - The banking sector is regulated under a new law (number 020/2007) of 13 March 2007, which replaced rule 95-011 of 17 July 1995, but implementation requires the passage of various regulations. The Government, with assistance from the World Bank and the Bank of France (Banque de France), and in consultation with the IMF, is scheduled to adopt by end-December 2008 all the implementing regulations to make effective the new law (IMF, 2007b: 32). Financial reforms, which began in the mid-1990s, have led to the privatization of the banking system and closure of several development banks. Since 2005, tightened banking supervision, particularly through on-site inspections in all banks, has led to better provisioning for non-performing loans. The Mauritanian authorities have launched a major reform programme primarily of the legal and regulatory framework of the financial system and for microfinance institutions, the foreign exchange market, and the money market. The payments system is also being modernized with the imminent start of an interbank electronic payments system. As part of the ongoing IMF supported financial sector reform programme, a recent IMF staff report on Mauritania (IMF, 2007b: 13) reported that the authorities should continue to pursue financial sector reforms, with a view to facilitating access to banking services and increasing competition. The report argues that efforts in this area should focus on enhancing the regulatory framework and banking supervision, recapitalizing domestic banks, reducing nonperforming loans, improving judicial support to banks' mobilization of loan guarantees, and modernizing the payment and accounting systems. Further financial system development, and increased competition (within a framework of proper and prudent licensing and supervision) will both be key to lowering the cost of loans and increasing enterprises access to finance. Further legal and institutional reforms are also required to establish a fully functioning modern financial system – for example, to introduce a modern bankruptcy framework and reform the juridical system.

Mauritania's financial system is characterized by a low level of bank penetration among the population (approximately 125,000 accounts for 3 million inhabitants) and the M2/GDP ratio has remained at about 13 per cent in recent years for which data are available (see table 2.1) and thus remains largely a cash-based economy. The financial system continues to be dominated by a small group of domestic commercial banks - 10 in June 2007 – although two foreign banks (Société Générale and BNP Paribas) established local operations during 2007. The domestic commercial banks are almost all affiliated with domestic family-owned business groups (conglomerates) and mostly act as financing arms

for these business groups (Tahari *et al.*, 2007; discussions with Central Bank of Mauritania). This may present risks to banking system safety and stability as related-party lending is pervasive and often extended at preferential terms, but also leads to restricted access to financial services by creditworthy borrowers outside these business groups. They are physically present mainly in the two largest cities, Nouakchott and Nouadhibou, and generally have no rural presence, where financing is left largely to informal sector finance and microfinance programmes to the limited extent that the latter do operate in rural areas.

The banking system therefore has traditionally been characterized by a low degree of competition as most banks have concentrated on financing their conglomerate and have had little incentive to engage in much outside lending. The central bank, which regulates the financial market except the insurance companies, has sought to stimulate competition between banks while improving oversight in the banking sector, and reduce commercial bank interest rates to improve access to finance. The entry of Société Générale and BNP Paribas has been welcomed by the Government with the hope that this will create greater competition in the banking system. Encouraging the entry of reputable foreign banks was a recommendation made by the IMF as part of its Financial Sector Assessment Programme (FSAP) for Mauritania undertaken during 2006 (IMF, 2007b: 51). It is too early to assess the impact of their entry, but there is the potential for increased competition and the introduction of new products, improved banking services and more modern banking management. This could upgrade the level of financial services available by introducing, for example, credit card facilities, which were not available in mid-2007. There is also the potential to displace less competitive domestic banks in profitable business segments and reduce their profitability, which could threaten their solvency, so proper bank supervision will become more critical.

**Development banks** - There were several development banks operating in Mauritania, but these were not very profitable and were closed during the financial reform programmes that aimed to privatize the banking system and move to a more market-based financial system. There exist few alternatives to commercial banks as financing institutions as non-bank financial institutions remain at a very early stage of development, although both microfinance and insurance activities have expanded in recent years.

**Insurance industry** - The insurance sector has enjoyed strong growth in recent years (averaging 23 per cent a year during 2001–2004) but remains underdeveloped. The total volume of annual premiums is only about \$10 million, representing insurance penetration of 0.75 per cent of GDP and a density of \$3.4 dollars for each inhabitant. These two indicators are lower than those for the Maghreb countries, but comparable to those for the other countries in the subregion (Tahari *et al.*, 2007; discussions with Central Bank of Mauritania). The insurance sector is underdeveloped, with total assets equivalent to less than 1 per cent of GDP. The insurance sector was reformed and liberalized in 1994 but regulated by the insurance code of 20 July 1993 (law 93-40). Six private companies have entered the market and now compete with the State-owned insurance firm (Tahari *et al.*, 2007). The early stage of development of the insurance industry also creates challenges for Mauritania. Insurance is a prerequisite to effective participation in production and particularly in international trade. The absence of any type of developed mechanisms for export credit insurance is an additional constraint for exporters.

**Microfinance** - During the past two decades, and particularly since around 1997, there have been several official programmes aimed at developing microfinance schemes. These have

generally been supported by funding and technical assistance from donors, international agencies and development banks. Microfinance institutions (mainly credit and savings banks that are contributory or cooperative in nature) have proliferated, but much of this activity takes place outside the regulatory framework. The institutions are heavily dependent on external financing, both to support credit activity and for their capital needs (IMF, 2007b; local press reports; discussions with Central Bank of Mauritania). Since 1998, Mauritania has been one of the 10 beneficiary countries of the pilot programme called the African Development Fund Microfinance Initiative in Africa (AMINA) created by the African Development Bank as part of the effort at poverty reduction under the PRSP-2. It has sought to provide training to 1,500 micro and small entrepreneurs and to 20,000 microfinance institution clients. With the support of the United Nations Development Programme (UNDP) and in coordination with the World Bank, the African Development Bank, the IMF, and the commercial banks, Mauritania finalized the implementing regulations required to implement the law on microfinance, and implementation of the law began in 2007 (IMF, 2007a and 2007b: 26; local press reports).

Microfinance has been used as a tool of poverty reduction in many poor countries, and has been used (and continues to be used) as a tool for the same purpose in Mauritania to support micro entrepreneurs. However, despite the gradual transformation of the microfinance environment and the significant commitment of institutional and technical partners, microfinance development is plagued with the following major problems: insufficient resources; a low level of professionalization; imbalanced distribution of MFIs (microfinance institutions), since very few of them operate in rural areas and their interventions are concentrated in the city of Nouakchott and a few towns inland; the notion of interest rates is at variance with religious beliefs; an inadequate legal and regulatory framework; and the non-involvement of the conventional financial system in MFI financing, since there are no guarantee mechanisms to encourage banks to refinance microfinance institutions (ADB, 2005).

The principal microfinance institutions include the following: savings and credit unions (les caisses populaires d'épargne et de crédit (CAPEC)), savings unions for artisans (les caisses d'Épargne et de Crédit des Artisans (CECA)), Nissa bank (Nissa Banque), mutuals (les mutuelles d'investissement et de crédit oasiens (MICO)), and a national union of savings cooperatives (l'Union Nationale des Coopératives Agricoles de Crédit et d'Épargne de Mauritanie (UNCACEM)). Microfinance can be effective in reducing poverty – there are no statistics on which to judge their impact in Mauritania. It is important to note, however, the fact that most microenterprises do not grow into medium-sized or large enterprises, and, while of great value, must be seen as a complement to credit for medium-sized and even large enterprises which have a greater chance of upgrading technologically, competing internationally and providing increased income, investment and productive employment.

**Capital markets, venture capital and seed capital, innovation and technology funds** - In many countries commercial banks do not act as a major source of finance for SMEs and start-ups (new enterprises just being established). In some, capital markets, venture capital funds, innovation funds, business angels and mechanisms for providing seed capital help to fill this role. In Mauritania, there is no stock or bond market, venture capital is not developed and there are no known organized sources of seed capital currently in existence. There are no innovation funds or other types of scheme to specifically target finance for innovative activities or innovative enterprises, or technology development funds to finance technological

upgrading or technology development. It is unlikely that the conditions for establishing a functional stock exchange exist given the dearth of medium-sized and large enterprises and the fact that most SOEs have already been privatized. The lack of financing opportunities for promising start-ups, and for SMEs in general, represents a market failure that strongly limits private sector development in Mauritania.

**Summary** - The national savings rate is low, as would be expected in a low-income country, which means that there are perhaps more limited prospects for large-scale financing of enterprises from household savings mobilized through the banking system than for countries with higher savings rates. Still, the savings that have actually been mobilized are, paradoxically, not being effectively channeled into long-term financing for SMEs and new business start-ups and there is actually excess liquidity (unused funds beyond those that must be retained for prudential regulatory reasons) among the banks. This is a common finding in LDC banking systems, and even other more developed developing countries as well. In many developing countries banks are arguably not best suited to SME lending in general and often face large disincentives to such lending such as high transactions costs and large information asymmetries related to lack of credit histories that lead to perceptions of SME lending as high risk.

Due to the heavy reliance of the economy on commercial banks, their low rate of penetration in the economy and the low level of availability and high cost of financing for start-ups and SMEs, most entrepreneurs rely upon family savings, retained earnings for enterprises that already exist and are profitable, or ventures with foreign investors who can provide financing. Microfinance is growing, and can serve a useful purpose, but is unable to fill the financing void because it is targeted specifically at micro and small entrepreneurs and microenterprises (which generally are very limited in growth prospects and are less likely to be internationally competitive) and not at medium-sized (or large) enterprises, which are likely to have larger financing needs. Access to outside (of the enterprise) finance therefore represents a major challenge to both starting a business and to expanding established enterprises. At present, this renders the reinvestment of internally generated profits a critical source of expansion financing, with the implication that developing a dynamic profit-investment nexus within existing enterprises will be key to enterprise financing. This in turn demands productivity levels and business volume at high enough levels to create profits for reinvestment. Creating these opportunities imply the need for developing technological capabilities among firms and promoting entrepreneurship. For the future, consideration should be given to the types of policy interventions that would be appropriate and feasible in developing financing mechanisms and incentives to fund promising startups and innovative, successful SMEs. This might include, for example, tax incentives to local banks for such lending.

This also means that financial reform and financial deepening should continue, with the aims, inter alia, of increasing competition in the banking industry, improving access to finance, reducing its cost, building non-bank financial institutions and promoting mechanisms to improve domestic resource mobilization and mechanisms to channel finance into productive ends. The development of credit bureaus, modern bankruptcy laws and other aspects of legal and institutional reform will need to support further financial sector development. Consideration could also be accorded to the design of mechanisms to promote more direct access to finance for innovative enterprises that hold the promise of fast growth and employment creation. This could be achieved through the creation of a development

bank or an innovation fund, for example, but the financing and management would be key issues in light of continued aid dependency and the need to avoid creating heavy additional financing requirements. Measures to improve access to finance may need to be combined with policies to promote the development of STI capabilities among promising enterprises (including entrepreneurial and management skills) and measures to provide business support services to assist private sector development.

## 4.2 Regulatory regimes to promote innovation

Regulatory regimes can be used by Governments to facilitate or stimulate innovation. In this respect, Intellectual Property Rights (IPRs) and quality (and other) standards are the major areas for consideration, and these are covered in this section. It must be noted, however, that such regimes have to be tailored to prevailing development conditions in order to be effective mechanisms to support innovation.

**Intellectual property rights** - Intellectual property rights (IPRs) represent an important element in the legal and regulatory framework that provides a system of incentives to domestic innovation and to the inward transfer of technology. IPRs are the source of ongoing heated controversy regarding their role in promoting or hindering both innovation and the transfer of technology. It is important to note that intellectual property (IP) protection represents only one of several elements that determine the ability of a country to innovate or to access technology from abroad (i.e. experience inward technology transfer).

IPRs can theoretically both increase and decrease innovation via two different channels. By providing exclusionary rights and financial returns to an innovation, they provide an incentive to people and firms to invest in learning and innovation, particularly useful to encouraging risky R&D (e.g. new drug development) and overcome market failures that promote less than socially optimal amounts of such investment. Also, by requiring disclosure of useful knowledge, patents help diffuse this knowledge beyond the inventor. But by increasing the cost of access to new knowledge, IPRs also raise a barrier to diffusion of this knowledge, make learning more costly, and may make both imitation and follow-on, complementary innovation more costly and so discourage them. So IPRs can create opposite effects on learning and innovation, with the final balance (a net increase or net decrease) being ambiguous. The impact then becomes an empirical issue, but measurement is very difficult and debate continues. Still, there is no clear empirical evidence that IPRs automatically lead to learning and innovation (see UNCTAD, 2007a).

For all countries, the incentive to innovate provided by IPRs will only increase innovation if the conditions needed for people and firms to innovate are present. The ability of a country to innovate technologically depends upon the amount of investment in innovative activities, access to foreign technologies, the state of domestic STI capabilities (that determine absorptive capacity for foreign technologies and the ability to create new technologies) and the strength of the NSI and sub-national innovation systems (including in particular access to finance, factors of production and key STI infrastructure). These are more advanced in developed countries, but less so in LDCs. So IPRs are in principle more likely to be more effective in the former. It is notable that the effects of IPRs can also vary by industry in addition to by level of development and technological capabilities.

Their impact on innovation may therefore be highly contextual. The impact of IPRs on the inward transfer of technology may also depend in part on the size of the domestic market and prospects for profitable market-based transfers of technology. For very poor countries, the likelihood of absorptive capabilities adequate for successful copying of complex technologies may be seen as low and make technology owners less disinclined to transfer technology to them. For Mauritania, the potential market is very small, which will have important implications.

Mauritania is in the process of establishing high IPR standards, being a signatory of several important IP agreements due to its membership of the World Trade Organization (WTO) since 1995, the African Intellectual Property Organization (AOIP) (OAPI: Organisation Africaine de la Propriété Intellectuelle) since 1963 and the World Intellectual Property Organization (WIPO) since 1976. As a result, they are a signatory to the WTO TRIPS Agreement (Trade Related Aspects of Intellectual Property Rights) due to membership of the WTO, the Bangui Agreement of 1977 (that was revised in 1999) due to membership of AOIP, the Paris Convention for the Protection of Industrial Property and the Berne Convention for the Protection of Literary and Artistic Works due to membership of WIPO. As an LDC, Mauritania is not subject to the terms of the TRIPS agreement until 2013 (and 2016 for pharmaceuticals), so that its IP regime is effectively that of the Bangui Agreement.

The Ministry of Trade and Industry (MTI) is also the focal point for the AOIP, and transmits requests of Mauritanian patent holders for brand registration of patents or commercial brand names through its Industrial Development Department. Table 2.10 reports comparative figures of innovations for Mauritania and selected comparator countries for 2004 and 2005. Mauritania's innovation performance based upon these data can be judged as relatively weak compared to other countries in the subregion, particularly with respect to brand names, but also with respect to patenting activity. Senegal and Cameroun are relatively strong innovators among these countries, although even their performance is weak compared to the most innovative African countries judging by patent data - South Africa and Egypt –and the intermediate countries including Morocco, Tunisia, Algeria, Kenya, Nigeria and Mauritius.

**Standards, certification and quality regulation** - Mauritania does not currently implement any generalized standardization or industrial control of quality systems, so local products are not subjected to any domestic quality standards, although the institutional mechanism exists for the development of such standards within the Ministry of Trade and Industry's Department for Standardization and Quality Promotion (DSQP). DSQP is entrusted with the technical aspects of standardization and quality, namely, the development, implementation and follow up of national and international instruments in respect of Standardization, Certification, Accreditation and Metrology; the promotion of standardization, quality and metrology activities, the monitoring of product quality and the promotion of the quality of industrial and commercial products.

With regard to technical education and training for technical trades such as electricians, mechanics, masons, carpenters, technicians, etc., there is also a need for standards and certifying bodies that provide certifications. This is reportedly also lacking today and is another deficiency that should be remedied, although responsibility may not fall under the same ministry.

The development and enforcement of domestic quality standards, and their incremental improvement over time, is an important tool for encouraging, or forcing, domestic enterprises to invest in technological upgrading through training and acquisition of improved technologies. This can apply to all economic sectors, primary, secondary and tertiary. Adherence to standards is an unavoidable part of many export industries. They are necessary in manufacturing exports as well as in fisheries, livestock and agriculture. The ability of fish exporters to meet EU SPS standards, for example, is critical for continued export of fish to the EU by domestic fishing enterprises. Establishing and maintaining the testing and certification infrastructure needed to monitor quality standards is a challenge in Mauritania, as in other LDCs. Standards have played an important role in the most dynamic developing countries that have used STI successfully to grow quickly and diversify domestic production. The development of standards should be used as an additional incentive to increased competitive pressure that has already been unleashed in Mauritania through the liberalization of trade and the entry of foreign enterprises through FDI. The corresponding issue of the ability of most domestic firms to successfully undertake such investment without support of some form, and with a poorly functioning financial system, is a related issue that must be addressed, especially given the predominance of micro-enterprises with limited financing and human capital.

### 4.3 Infrastructure

Transport, communications, power and water supplies are important elements in the enabling environment for STI activities. In industrialized countries, well-functioning physical infrastructure and utilities are generally taken for granted, and so are not given much emphasis as “enabling conditions” for innovation. In contrast, in countries where they are seriously inadequate, or impaired, they tend to act as significant barriers to technological development. Therefore, in assessing STI capacity in an LDC like Mauritania, physical infrastructure and utilities are usually important components of the national innovation system.

**Transport infrastructure** - As noted, deficient transport infrastructure represents a major constraint for many enterprises in Mauritania and raises the overall cost of production and trade, and represents an additional hurdle in developing successful export activities. Discussions in the country highlighted in particular the key issues of deficiencies in sea ports and road networks. The large physical size of the country, its low population density and the scattered population among three main geographic areas (the capital Nouakchott, the second city of Nouadhibou (the center for fishing and mining) and the agricultural/rural area near the Senegal river) combined with the national low income level create a challenging environment for creating and maintaining a modern and efficient transport infrastructure.

The ports are the major route for trade flows. Limitations on port capacity are reported to present an important constraint on efficiency in import and export of products, despite the construction of the latter seaport and its entry into service in 1987 significantly improved capacity at the time. The two existing ports at Noudhibou (critical for mineral and fish exports) and Nouakchott (handling most imported goods) are both relatively small and cannot accommodate docking by the largest container ships. Total export and import traffic tonnage via the port at Nouakchott for 2007 was only 2.3 million tons, which nevertheless represents a marked rise over 2006 and all previous years. Ensuring adequate maintenance

is reported to represent a major challenge. Poor coordination of the port system reportedly constitutes another significant issue. Port fees are two to two-and-a-half times greater and handling charges are four to eight times higher at Nouakchott than in the sub-region. The seaport and road network deficiencies and the related high costs of trade are a sub-regional issue given the relatively small volume of seaport traffic generated by the sub-region which means that the current network of seaports is naturally much less efficient and higher cost than some other developing and developed geographical regions where goods traffic is much heavier and seaport capacity is much larger, allowing larger seaports and greater economies of scale.

The large size of the country and dispersed population presents a challenge for the road network in particular. Investments in road infrastructure over the 2001–2004 period went into increasing the size of the road network and further efforts to improve the state of roads. The road network comprised only 7,660 km in 2004 of which just 11.3 per cent was paved, translating into a network density of 7.5km/1,000km<sup>2</sup> - the lowest density among the LDCs in 2004 (for which data were available) after the Sudan where road density was 5.0km/1000km<sup>2</sup>. The extremely low density is a result of the scarcity of roads as well as the large land mass (in both countries). The projects carried out during the four years went into, among other things, road maintenance, the repair of various sections of the *route de l'Espoir* (Road of Hope) and the construction of the Aïoun-Nioro, Rosso-Boghé (currently underway), Tiguent–Nimjatt, and Nouakchott–Nouadhibou highways and in urban roads, mainly in Nouakchott. The secondary road network is still extremely disadvantaged (60 per cent of the dirt roads are passable, albeit with severe risk of breaking down in the rainy season). The high cost of maintaining existing roads has typically absorbed much of the road work budget, given the need to continuously clear them of desert sand blowing over them.

**Telecommunications and ICTs** - ICTs are widely acknowledged as a critical platform or infrastructure technology for enabling efficient and effective communication and increased access to useful information and knowledge. Government has put great effort into improving the ICT industries by establishing a better ICT infrastructure, improving access to ICT and improving ICT services, and significant progress has been made since 2000. Progress in terms of mobile telephony (arguably the “easiest” of the modern technologies to transfer and diffuse in poor countries) has been dramatic, but it has been much slower in raising computer and Internet access and quality (progress on creating broadband Internet access included). Inadequate information flows remain a handicap to productive activity throughout the economy, especially in rural areas. A genuinely effective ICT performance would need to reverse this and act as a channel for greatly improved information and knowledge flows, and promote much stronger linkages among the actors in the NSI. Improving information flows to rural populations active in agriculture and livestock production would, for example, facilitate exports to neighbouring countries (Integrated Framework for LDCs, 2001).

The progress that has been made since 2000 was made possible due to widespread international efforts targeted at improving ICT in developing countries and the realization in Mauritania of the usefulness of improving ICT access. This led to regulatory reform in the ICT sector and the creation of several national ICT strategies and programmes, some elements of which were implemented in collaboration with different stakeholders including donors, international organizations and private companies. The impact of improved ICT has clearly been positive in both economic and social terms based upon in-country discussions and experience in the country, but hard indicators to support this assertion, or to measure the

degree of impact – and its dispersion among enterprises, Government and households – are not available. One simple measure of progress is the reduction in the cost of telephone calls since 2000.

The formulation of Mauritania's National Information and Communication Infrastructure (NICI) plan started in April 1999. The process was led and coordinated by the Science and Technology Faculty of the Université de Nouakchott and the Ministry of Interior and Communications with support from the Internet Initiative for Africa of the UNDP as part of the national NICI team and the Economic Commission for Africa (ECA) (Agyeman, 2007; Hamady, 2004). The NICI plan was finalized and approved in March 2000. The plan aimed to integrate the ICT dimension into the realization of the strategic choices for economic and social development in Mauritania, to democratize access to ICT, to contribute to the establishment of mechanisms of good governance and to position the country to participate in the globalization process. In September 2001, the Government created the State Secretariat for New Information Technologies (Le Secrétariat d'Etat auprès du Premier Ministre chargé des Technologies Nouvelles) (SETN) in the Office of the Prime Minister to prepare and promote the national ICT policy. The new Government converted the SETN into a Ministerial Department and merged it with hydraulics and energy under the new Ministry of Hydraulics, Energy and Information Technologies.

SETN developed and launched a 2002-2006 national strategy for the development of ICT in Mauritania, including the development of telecoms and ICT services and promotion of their use within the private sector, Government and society more broadly. Liberalization of the telecoms industry began in 2001. Various actions were undertaken as a result, including: (i) implementation of multiple training programmes and establishment of a CISCO academy at the Ecole Nationale d'Administration (ENA); (ii) start up of the development of the fiber optic administrative network; (iii) preparation of comprehensive information technology plans for several ministerial departments; (iv) review of the legal and regulatory framework; (v) national telemedicine project; and (vi) start-up of the activities of the remote training center (Centre de formation et d'échanges à distance de Mauritanie (CFED)) and the Mauritanian Development Portal (PMD). At the same time, internet and data services, which had remained the exclusive domain of the historic carrier with regard to network provision, benefited from the strengthening of the internet node with the bandwidth offered increasing from 128 Kbps to almost 10 Megabits (Government of the Islamic Republic of Mauritania, 2005).

In the context of the Poverty Reduction Strategy Paper (PRSP), the ICT objectives are to increase the coverage rate of telecom infrastructures (land/cell) to 85 per cent and 27 telephones per 100 population by the year 2010. Other actions to be undertaken include: conducting studies on enhancing Mauritania's international telecommunications connections; deploying land line and cell networks over large areas; renewing obsolete communication network equipment and local administration security; enhancing competition between cellular phone operators; and enhancing the capacity to raise financing (Government of the Islamic Republic of Mauritania, 2007).

The results achieved to date have fallen short of some of the targets envisaged in the ICT strategies, but major progress has nevertheless been achieved. The number of business transactions. They can have a large positive impact on entrepreneurs and enterprises that do not have other effective means of communication. However, computer technology and

internet access are far more important as a means for accessing, sharing and storing information, and in particular knowledge, and for conducting research. They are critical for effective collaboration on international R&D projects. The slow diffusion of computers and internet access remain important obstacles to learning and knowledge accumulation.

The ICT sector is also characterized by a lack of qualified staff – a situation which is exacerbated by the exodus of skilled workers abroad (Islamic Republic of Mauritania, 2007). Training information systems specialists who have the capabilities of developing and promoting added-value services remains a necessity. Access to computer hardware and Internet remains low (one computer per 300 persons in 2004) and its cost remains high. The low number of computer users is likely due to both the cost of acquisition of data-processing equipment and of connections. Anecdotal evidence from in-country discussions indicates only a limited effectiveness in absorbing the technology (in terms of efficiency in computer software use both among enterprises and households). Absorptive capacity has been limited by the weakness of the educational system and the lack of competences among a substantial portion of the population in the use of ICT.<sup>23</sup> Among enterprises, the low priority generally placed upon staff training means that inefficient use of software is likely to continue, limiting the potential positive impact on productivity. There are, of course, notable exceptions among large national enterprises such as SNIM and innovative firms that invest in training and technology upgrading, such as the ASML Group.

However, the rate of growth in mobile phone access has been faster than expected, with cellular services rapidly expanding, as in many African countries that face severe constraints on fixed line telephony. Several telecoms firms active locally confirmed that the expansion in mobile phone purchases and subscriptions in recent years has been much faster than the firms had projected. Foreign telecoms TNCs from within the sub-region that have entered since 2000 have played a large role in meeting the rapid expansion in local demand for mobile services. Four months after mobile telecommunications networks were introduced in November 2000, the number of mobile telephones exceeded the number of fixed lines (Economist Intelligence Unit, 2003).<sup>24</sup>

There are currently three mobile telephone operators in the country, all of them partly foreign-owned: Mauritel Mobiles of Mauritel SA, Mattel S.A. (Mauritano-Tunissienne de Telecommunications) and Chinguitel Mauritanie. Mauritel is the original State-owned fixed line telephone monopoly operator that was privatized in 2001 with a 54 per cent stake bought by Maroc Telecom (of Morocco). Tunisie Télécom (of Tunisia) holds a 54 per cent stake in Mattel. In 2006, Mauritania licensed Chinguitel Mauritanie S.A., owned by a consortium that includes Sudanese telecoms company Sudatel and a number of Mauritanian investors, as a new mobile operator. Chinguitel, launched its services in Mauritania in August 2007. Since 2004, Mauritel has lost its place as the sole national carrier for fixed telephone services, though it is still the only operator of fixed phone lines in Mauritania with a penetration rate of

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<sup>23</sup> Information in this section comes in part from direct interviews with the previous Secretary of State in charge of ICT in Mauritania and several companies involved in ICT in the country.

<sup>24</sup> There is no data that would allow any judgement to be made on whether mobile phones are used largely for social purposes or for business purposes such as organizing business meetings or collecting information on prices for products for fishermen or farmers (as has been reported in several isolated case studies in other developing countries).

Table 4.2. ICT Statistics for Mauritania and selected countries

		Mauritania	Mali	Senegal	Tunisia	Algeria	Morocco	South Africa	Ghana	Kenya	Malaysia
ICT-OI Index (a)	2007	43.38	22.92	47.11	95.12	75.55	79.5	96.78	40.23	42.26	150.19
Networks Index (a)	2007	37.3	19.9	38.9	107.1	79.9	73.1	104.7	30.9	25.9	133.3
Skills Index (a)	2007	59.4	24.0	43.8	99.2	94.6	68.8	101.0	71.1	73.2	104.7
Uptake Index (a)	2007	22.0	8.0	36.2	93.6	45.4	78.5	96.3	16.6	23.7	244.3
Intensity Index (a)	2007	72.74	71.74	79.78	82.35	94.83	101.15	86.15	71.76	70.97	149.28
Telephone mainlines (per 100 people) (b)	2000	0.7	0.3	1.9	9.9	5.7	5.0	11.2	1.0	0.9	19.9
	2006	1.1	0.6	2.3	12.5	8.5	4.1	..	1.5	0.8	16.6
Fixed line and mobile phone subscribers (per 100 people) (b)	2000	1.3	0.4	4.4	11.2	6.0	13.2	30.2	1.7	1.3	41.9
	2006	35.9	13.3	27.0	84.9	71.4	56.6	..	24.1	18.5	91.1
Mobile phone subscribers (per 100 people) (b)	2000	0.5	0.1	2.4	1.2	0.2	8.2	18.9	0.6	0.4	22.0
	2006	34.8	12.6	24.7	72.4	62.9	52.4	..	22.6	17.7	74.5
Internet users (per 100 people) (b)	2000	0.1	0.1	0.3	2.7	0.4	0.7	5.4	0.1	0.3	21.3
	2006	3.2	0.5	5.3	12.7	7.3	20.0	..	2.6	7.5	43.2
Personal computers (per 100 people) (b)	2000	0.9	0.1	1.5	2.1	0.6	1.2	6.5	0.2	0.4	9.4
	2006	..	..	..	6.2	..	..	..	..	..	..
Broadband subscribers (per 100 people) (b)	2000	..	..	..	0	..	..	0	..	..	0
	2006	0.02	0.02	0.2	..	..	1.2	..	0.05	..	3.4

Sources: (a) ITU database; (b) World Bank WDI Online Database (June 2008).

Note: The ITU data are available at <http://www.itu.int/ITU-D/ict/publications/ict-oi/2007>.

1.6 per cent covering all the major cities. Mauritel launched ADSL services early in 2006 (Agyeman, 2007). The rate of penetration of cellular telephones is about 23 per cent with Mauritel covering about 70 per cent of the market. There is, therefore, in principle competition among service providers, although a number of local actors argued that there needs to be an improvement in both the price and quality of services provided.

The overall impact of ICT improvement in Mauritania has very likely been positive although actually measuring these impacts is difficult. It has likely been strongest from higher mobile phone access, given the limited expansion in computer and Internet access. The positive economic and social impacts have likely been spread among both enterprises and society more widely (households and Government) through increased communication capabilities that have probably reduced transactions costs and increased access to information. The Government is pursuing e-government initiatives to improve its efficiency of operations and reduce the cost of access to Government services. The impact has likely been especially high in the two main urban areas of Nouakchott and Nouadhibou which both have relatively good mobile phone network coverage and relatively high penetration rates among the population, and other smaller urban centers. Network coverage is less available in isolated rural and desert areas, where communication remains relatively difficult.

The high cost of access and services was reported to remain an important issue for mobile phone services, due in large part to the small local market reflecting a small population with low buying power, and the resulting difficulties in achieving economies of scale in services provision and the need to amortize infrastructure costs over a small customer base. The impact of mobile telephony may also be limited by the unused potential for using the technology for an increased range of functions, such as for banking transactions, that is becoming more widespread in some African countries. The issues of how to measure the impacts of expanding mobile phone use in poor countries, both theoretically and in terms of practical methods at the country level, requires further attention. It seems likely that to enable ICT use as an effective means of accessing useful knowledge, for learning and for building STI capabilities, the country will need much higher penetration of Internet access and adequate broadband availability (at a minimum for centers of learning and R&D for a start), which implies accordingly increased computer penetration. Therefore, as a tool for learning, knowledge accumulation and generation, and innovation through applying existing knowledge, ICT likely play a limited role for most enterprises and people in Mauritania at present. They have also not been diffused adequately to make research efforts more effective by enabling easy access to publications as noted in IDRC (2005). An indication of this is the deficiencies in computer terminals and Internet access even at the University of Nouakchott.

The potential for use of ICT for accessing and sharing information and knowledge clearly exists. The distance education centre (CFED), discussed under the section the education system, is one important example. The establishment of the Mauritanian Development Gateway (Portail Mauritanien de Développement) or PMD in 2002 with World Bank support is another. PMD is the first development internet Portal to facilitate global information sharing. It is officially aimed at developing Mauritania's integration into the global digital economy by: setting up a common information, communications, transactions and training space; building and upgrading local content and capacity; catalyzing emergence of national knowledge management systems; promoting the country's reputation, as an attractive place for business; promoting e-commerce, e-banking, e-government, e-training and e-communities; and increasing global competitiveness of the country through greater

institutional transparency and lower transaction costs. The impact of PMD in improving information and knowledge flows within the country and with other countries is not known, but its activities are a positive step in improving these flows. Both these initiatives were made possible through international collaboration, illustrating as well the importance of such international collaboration to technological upgrading in Mauritania.

**Power supply** - Inadequate electrical power supply represents another important constraint to expanding economic activity and to social development in Mauritania. Current electricity production is inadequate, allowing marginal scope for meeting peak demand. There are periodic power cuts in Nouakchott that have meant that larger enterprises use personal power generators. Microenterprises and SMEs may be more subject to power outages. Total electricity generation and consumption have both been rising gradually year by year throughout the past 10 years. The country generates 105 megawatts of electricity. Fossil fuels provide 44 megawatts and hydroelectricity 61 megawatts. About 15 per cent of the Mauritanian population has electricity with 30 per cent in the urban areas and 10 per cent in rural areas (Agyeman, 2007). In 2004, electricity consumption per capita was approximately 55 Kilowatt-hours (ADB, 2007).

The country requires additional energy capacity, facing current shortages and with domestic energy demand rising rapidly particularly in the capital, where the population is growing quickly – reported at some 10 per cent per year<sup>25</sup> – due to a strong rural–urban migration. This is a challenge common to many African countries and indeed many developing countries outside Africa as well. To date, solar energy has been used only to a very limited extent in power generation despite the large energy potential involved. There are plans to increase the exploitation of solar and wind energy. There is also a possibility that recently discovered gas reserves may be used as a commercially feasible source of energy for domestic use. These potential solutions all require the application of existing knowledge and technologies as well as sources of project finance to fund infrastructure development.

The monopoly that Sonelec (*la Société nationale d'eau et d'électricité*), the national electricity generation and distribution company, enjoyed was abrogated in 1999. Two companies resulted: Somelec (*la Société mauritanienne d'électricité*) and Ader (*L'Agence de développement de l'électrification rurale*). Ader is responsible for rural electrification and Somelec handles power generation and distribution. SNIM (*La Société Nationale Industrielle et Minière*), also produces 40 megawatts and 8 megawatts of electricity in its mining towns of Zouerat and Nouadhibou, respectively (Agyeman, 2007). Government has considered the possibility of private sector involvement in the electricity industry and the possible privatization of Somelec, but attracting foreign investors and foreign enterprises active in electricity may be a challenge in a small market with limited effective purchasing power.

Mali, Senegal, and Mauritania constructed the Manantali Dam on the Senegal River. The dam is managed by Sogem (*la Société de Gestion de l'Énergie de Manatali*) and provides 807 GWh per year to the three countries with Mauritania obtaining 15 per cent of power generated since 2002 (Agyeman, 2007). The dam has therefore been important for electricity generation, in addition to its role in facilitating the development of irrigated (as opposed to rainfed) agriculture in the Senegal River basin during the 1980s.

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<sup>25</sup> Government of the Islamic Republic of Mauritania (2001: 10).

Plans are afoot to provide electricity for 80 per cent of the population in the two major cities of Nouakchott and Nouadhibou. The national demand accretion rate is between 10 per cent and 15 per cent (Agyeman, 2007). An ambitious infrastructure investment programme is planned, consisting of four programmes. The first programme is to extend the electrical grid system to additional communities not yet served, with the electrification of 30 communities (24 of which are *moughataa* capitals not yet connected to the electrical grid) and the extension of the Manantali electric grid in the valley (first along the Rosso–Boghé corridor, and then along the Boghé–Kaédi, Boghé–Aleg, Kaédi–Civé, and Civé–Maghama–Sélibaby corridors). The second programme is to rehabilitate and expand electricity generating facilities in Nouakchott (expansion of the existing electric power plant and construction of a new plant), in Nouadhibou (expansion and rehabilitation of the electric power plant, and construction of a wind farm), and in 13 other electrified urban centers (modernization and upgrading of thermal plants). The third programme is to extend electrical grid systems to Nouakchott and to Nouadhibou, and within other towns that have electrification. The fourth programme is to electrify additional communities using renewable energy sources (electrification using solar energy, particularly in the Hodh Chargui, Assaba, Adrar, and Inchiri regions; electrification using hybrid wind-diesel systems in coastal villages; and so forth) (Government of the Islamic Republic of Mauritania, 2007).

**Water resources** - In terms of environmental challenges, Mauritania faces threats from desertification, climate variability, periodic drought, general water scarcity, land and soil degradation, deforestation (related to desertification) and outbreaks of pests such as locusts. There are also fears of the potential for sea pollution resulting from offshore oil exploration and production, which could negatively impact on the marine environment and the fishing industry. Success in managing these challenges has depended upon the development of strategies by relevant Government ministries and the application of relevant useful knowledge and the related adoption of relevant technologies, often in collaboration with international actors. The ability to become aware of the technologies that are available and to select those that could be most useful locally require scientific and technological knowledge. The successful sourcing, absorption, adaptation and application of these technologies require additional STI capabilities. The authorities in charge of managing, monitoring and possibly redesigning these programmes also require adequate STI capabilities to ensure their sustainability and effectiveness beyond the initial implementation stage. STI capabilities must therefore be harnessed to successfully manage these environmental threats.

Desertification is a major issue in Mauritania, with 15 per cent of the country's territory being lost to desert between 1990 and 2000 alone (UNDP, 2007). The first national plan to address desertification (the Master Plan to Combat Desertification) was approved in August 1986. The Mauritanian National Action Plan against desertification, for example, explicitly recognizes the use of scientific and technical research as an essential tool against desertification. Some of these threats (such as desertification, climate variability, water scarcity and periodic drought) affect several countries simultaneously, including various countries in Mauritania's subregion (the Sahel region), and should ideally be addressed through sub-regional, regional and other international scientific and technological cooperation rather than through solely national efforts. On desertification, for example, Mauritania collaborates with other countries of the Sahel region, and with the United Nations Environment Programme (UNEP) and various other United Nations and other agencies under the United Nations Convention to Combat Desertification (UNCCD). Other countries outside the Sahel region also suffer from desertification and have innovated in designing solutions in part through experimentation. These innovations may have originated in any

area of the world faced with the problem, and effective solutions for Mauritania (and other affected countries) might come through the application of these ideas locally.

Water management is also important for Mauritania, given its centrality to human survival and to agricultural production, and its role in helping prevent mass rural-urban migration and reducing poverty by making rural development possible. It is also central to ensuring that the populations concentrated in cities, as well as enterprises involved in water intensive production activities, have reliable access to adequate water supplies of adequate quality. The main sources of water are rainfall and the Senegal River. The latter is the only sure source of water given variable rainfall patterns and periodic droughts over the past 30 years. These droughts have been a major catalyst for the marked urbanization of the population since independence.

Effective management of its water resources therefore requires the application of scientific knowledge and technology to measuring, mapping and monitoring water availability and to developing an integrated water management system. This system should ensure that suitable irrigation methods are employed in agriculture to make effective (non wasteful) and sustainable use of rainfall, underground water reserves and water from the Senegal River. The CNRE confirmed that currently rainfall is largely lost through evaporation, and it is important to devise more effective methods of using rainfall in order to preserve the other two sources of water. Local innovation is needed to make this possible by studying technologies in use elsewhere that may be appropriate for use in agriculture in Mauritania and introducing them locally. In practical terms, this will require co-ordination between the ministry for Energy, Water and ICT and those responsible for rural development and environmental issues. Effective water management requires sub-regional co-operation with Senegal as the Senegal River's water resources are shared by the two countries. Management of the Senegal River is provided by the office for the Exploitation of the Senegal River (OMVS), which coordinates with a national body in each country (SONADER in Mauritania and SAED in Senegal).

In Mauritania, national water policy is established by law number 030,2005 of February 2005. The Ministry of Energy, Water and ICT is in charge of the management of water resources, with the National Centre on Water Resources (CNRE) acting as a research centre to improve knowledge on water issues in the country. The research centre is an important tool to move towards making integrated water management possible by creating a database and geographic mapping of existing water resources throughout the country, monitoring water levels over time and studying water needs and use in all sectors of economic activity and among households. The centre has established several regional bases for this purpose, but is constrained by inadequate finance and deficient laboratory facilities.

#### **4.4 Basic human capital**

Human capital (healthy and educated people with good skills) is the most basic resource needed to build strong STI capabilities. Table 2.7 shows that in terms of adult literacy and the primary, secondary and tertiary enrolment ratio, Mauritania compares favourably with Mali and Senegal, but is in a weak position relative to other countries, particularly the best performers in Africa. The performance is particularly poor with respect to higher education in technical subjects (science and engineering) and manufacturing and construction, although data are not available for all countries. UNCTAD (2005: 291) ranked

Mauritania as having a very low human capital index in 2001, using a combination of the literacy rate, secondary enrolments and tertiary enrolments in all subjects. Clearly, the resource endowment in technical skills is very weak compared to the stronger performers of the region and elsewhere.

The gap in technical skills relative to fast-developing countries and developed ones is important not only in percentage of population comparisons but also, given its small population, in the actual number of technically skilled people. This makes it very difficult to fill technical positions needed to run enterprises or develop a critical mass of specialized skills in a wide variety of areas simultaneously. This means that expertise from abroad, and international collaboration (subregionally, regionally and out of region) is important.

Human capital is central to STI capabilities and building a strong NSI in any country as it is key to building the abilities for technological learning and upgrading as well as innovative capacity that support economic development. Human capital refers to a combination of human resources development and human health. Human resource development takes place through education and training. Mauritania has made significant progress in building its basic human capital through a strong emphasis on education. The adult literacy rate rose from 29 per cent in 1975 to 51 per cent in 2004.

However, partly because the country started from an extremely low base, human capital is still weaker than in neighbouring countries (such as Algeria or Tunisia) and far behind the most dynamic developing economies or the developed countries (see for example table 2.7 on adult literacy and enrolment ratios). There has been a dramatic increase in access to basic education as reflected in much higher enrolment rates in primary formal education since the 1980s (see table 4.4). Secondary enrolment rates have also increased significantly over this period, but remain relatively low, as do postsecondary enrolment rates which have hardly risen due to an increasing population combined with physical and material limits in the higher education system (in terms of infrastructure, rooms, equipment and teachers), including the technical and vocational education institutions.

In addition, there are challenges related to providing high quality education services, particularly in technical subjects such as mathematics, science and engineering, and in language skills. The lack of correspondence between the skills provided by the education system and those needed in the labour market was also a widely reported problem that represents a weakness in the NSI in terms of missing linkages between the educational institutions (the schools, the university and technical and vocational training centers) and industry. Thus, while the number of graduates has risen dramatically, the quality of both the formal education system and technical and vocational training was raised as a key issue by many in Mauritania, including the employers associations, private and State-owned enterprises, Government officials and others. There is a small group of highly educated and skilled people, but the rate of migration abroad of these people is high. The majority of nationals attending university abroad either remains abroad or returns only temporarily before returning abroad to find jobs. Thus, despite the dramatic progress made in comparison with, for example, the 1960s, the basic point remains that a weak human capital base, remains a major constraint. An indication of this is provided by the National Office of Statistics (ONS) which reported that for 2003, 60 per cent of job applicants had never been to school while only 10 per cent had reached a primary education. The education system has improved, but huge challenges remain.

Over the past three decades, Mauritania's education system has evolved significantly, passing through a series of reform programmes (in 1967, 1973, 1979 and 2002) aimed at establishing a system that responds to the socio-cultural and socio-economic needs of the country. The 1979 reform programme lasted for 20 years during which there was a dual education system separated by two languages of instruction (Arabic and French). The system was characterized by high enrolment ratios, but quality was poor as indicated by poor pupil performance and retention. Educational provision was costly because of the multiple human and material resources adapted to a dual system of education. Poor mastery of the languages was identified as one of the main reasons for weak pupil performance particularly in science subjects and the content of school curricula was not well adapted to the economic needs of the country.

The teaching options between French or Arabic higher education has been prejudicial to the quality of teaching delivery. The choice of instruction language was introduced in 1980, and nearly two thirds of the students chose Arabic instruction. This, in the absence of a national postgraduate curriculum, limits their access to technological knowledge at the universities of Europe and North America, and even within the Maghreb (Algeria, Morocco and Tunisia), where scientific postgraduate higher education is delivered in either French or English.

Continuing education sector reforms under the ten year PNDSE education reform programme launched in September 2002 with donor financial and technical support seek to remedy some major deficiencies. They include, inter alia, making technical and vocational training more responsive to market demands, putting greater emphasis on scientific subjects and promoting R&D and technological innovation in the higher education system.

Spending on education has represented a relatively low proportion of total Government spending in recent years for which data are available, accounting for 7.1 per cent of total expenditure in 2005 (table 4.3). This is low relative to neighbouring countries and much lower than African leaders in innovation such as South Africa.

**Table 4.3. Government expenditure on education**

In million UM 1US\$=273,3UM

	2001	2002	2003	2004	2005
Education expenditures	2.116	2.185	2.546	4.929	2.954
Total Budget	26.497	33.843	40.210	48.491	41.531
Education in % of total Budget	8.0%	6.5%	6.3%	10.1%	7.1%

Source: ONS Directory of Statistics 1995–2005.

**Education system and enrolment trends** - Pre-school education admits children aged 3 to 6. Since 2001 schooling is compulsory from the age of six. Basic education comprises six years of instruction and theoretically enrolls children aged 6 to 11. At the end of the cycle, pupils sit for the Elementary Studies Certificate exam and the entrance exam into the first year of secondary education. General secondary education comprises a first and second cycle of four and three years, respectively. There also exists a two year vocational training programme geared towards pupils either choosing not to pursue the Baccalaureat or failing the Baccalaureat. The higher education system in Mauritania is made up of the University of Nouakchott and five IHEs: (a) the higher teacher training school (*Ecole Normale Supérieure* - ENS), (b) the National Administration School (*Ecole Nationale d'Administration* - ENA), (c)

the Higher Technical Education Center (*Centre Supérieur d'Enseignement Technique-CSET*), (d) the Higher Institute for Islamic Studies and Research (*Institut Supérieur d'Etudes et de Recherche Islamique - ISERI*), and (e) the National Institute for Medical Studies (*Institut National des Spécialités Médicales - INSM*) (World Bank, 2004; ADF, 2001).

Mauritania has made consistent efforts to improve the overall level of education and skills of its population over the past 30 years as evidenced by the series of education reform programmes and the steady improvement of access to basic education, especially for girls. With the support of several IDA-financed education projects, coupled with efforts from other development agencies, the Government has expanded educational opportunities in primary and secondary education and in vocational and technical training (see table 4.4). As a result, the total gross enrollment ratio at the primary level increased from 41.5 per cent in 1985/86 to 91.6 per cent in 2002/03. Gross enrollment rates (GERs) at the first and second cycles of secondary school marked a modest increase from 14.8 per cent in 1985/86 to 24.5 per cent in 2002/03, and from 11.5 per cent in 1985/86 to 17.3 per cent in 2002/03, respectively (World Bank, 2001; World Bank, 2004; ADB, 2005).

The country has made dramatic gains in improving female access to education. In the education sub-sector, the gross enrollment ratio grew from 47 per cent in 1990 to 86 per cent in 1998. This improvement was accompanied by an improvement in the enrollment ratio for girls (83.5 per cent) to match the ratio for boys (87.6 per cent). Enrollment at the secondary level increased by 56 per cent from 35,221 in 1990/91 to 60,069 in 1998/99, with girls representing 41 per cent of the total. The number of students in technical education doubled from 880 to 1,682 with girls representing about one third of the total. Political will to improve education achievements, particularly those of girls and women, has been the main driving force behind those achievements (World Bank, 2001; ADB, 2005). In terms of equality, there is gender parity in elementary education, and the gap has closed in secondary education, although there are still disparities when it comes to the exam pass rates (Government of the Islamic Republic of Mauritania, 2007).

**Entrepreneurial capabilities** - Entrepreneurial capabilities – those related to establishing and successfully running a business enterprise – are central to creating and maintaining a dynamic private sector. Entrepreneurship is risky and many new business ventures fail. But entrepreneurs are critical to start new enterprises and to expand small enterprises into medium size ones, and medium size enterprises into large ones. In Mauritania, most enterprises are micro and small enterprises, and the private sector is poorly developed. There is little firm level data in Mauritania, and no reliable data on firm start up rates or survival rates. It is known, however, that many firms are small and informal, and that average productivity levels are low, as discussed in section 3.1.

### 4.5 Summary

The overall message from the discussion of Mauritania's investment climate is that, while progress may have been made in some respects, much more needs to be achieved to create a truly enabling investment environment that promotes high rates of investment and the development of a dynamic private sector. Given the weaknesses of enterprises in general with respect to STI capabilities and the cumulative obstacles to starting and operating a business, there is a need for business support services to improve STI capabilities (including entrepreneurship and management skills in addition to information on

markets and technologies and actions to facilitate access to finance for those who wish to start a business and those who are running businesses that have the potential to become successful). The lack of such public policies to assist micro-, small and medium-sized enterprises has in the past been identified by Government itself as a policy weakness, for example in Government of the Islamic Republic of Mauritania (2001: p. 6). The issues are what types of BDS are most needed, how they can be designed and targeted to specific enterprises, what institutional arrangements would be appropriate and where the funding for this will come from. Innovative approaches to providing financing for promising entrepreneurs and SMEs already in existence are also required.

Greater support to enterprises is certainly not the only policy avenue to improving enterprise STI capabilities and strengthening the NSI. It is critical that Government establish a framework that provides appropriate incentives for enterprises to build these capabilities of their own accord. In this respect, at least four channels should be pursued. The first is to use domestic standards to directly encourage enterprises to upgrade the quality of their products (goods and services), which will often require better capabilities. The issue of standards is addressed separately, with the finding that they are not actively used today as an instrument to promote upgrading.

The second is to increase the level of competition among enterprises by pursuing policies that create competitive conditions. This may involve various different areas of policy, including policies on market structure and competition to discourage monopolies and oligopolistic cartels, trade policies and FDI policies. The country has undertaken comprehensive reforms in these three areas. Trade policies can encourage exports (which automatically imply the need for competitive production methods on the part of exporters) and allow imports. Import liberalization introduces foreign competition because domestic producers must supply competing products at similar levels of price and quality in order to maintain their domestic market shares. Liberalizing imports of capital goods, machinery and equipment that act as intermediate inputs into domestic manufacturing is necessary to allow manufacturing to develop locally, and also serve to transfer technology from abroad as technology that is embodied in these goods. Policies to discourage monopolies and cartels, and to facilitate the ability of entrepreneurs to establish new domestic enterprises are also important. In Mauritania, most SOEs have been privatized, but preventing oligopolistic competition and abuse of market power appears to be difficult in light of the dominance of some business activities by a small number of relatively large domestic business groups and the limited number of competing enterprises. Nevertheless, strong competitive forces have been introduced through trade and FDI liberalization. Foreign direct investment (FDI) policies can also allow foreign entry and operation of TNCs where this would bring benefits such as new technology (broadly defined to include management etc.) or provide competitive stimulus to stagnant industries. Policies should aim to encourage linkages between them and domestic enterprises so that the domestic enterprises become part of international or regional value chains and provide a mechanism to upgrade their capabilities.

The third channel to provide incentives is the development of an appropriate system of intellectual property rights that will encourage and facilitate innovation in Mauritania, including in our definition the introduction of new technologies in the domestic production of goods and services. The fourth channel to provide incentives for upgrading is to pursue policies that promote an enabling business and investment environment and encourage the establishment of new, innovative enterprises as well as investment by more established ones.

Table 4.4. Student population and enrolment ratio 1985–2003

Academic year	1985-86	1990-91	1992-93	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
<b>Primary</b>											
Number of pupils	140,871	166,036	218,215	268,216	312,654	330,199	346,222	355,822	360,677	375,695	394,400
Population aged 6-11	339,448	355,073	350,747	352,815	365,119	399,518	405,356	411,706	417,191	423,357	430,398
Enrolment ratio (%)	<b>41.50%</b>	<b>46.80%</b>	<b>62.20%</b>	<b>76.00%</b>	<b>85.60%</b>	<b>82.60%</b>	<b>85.40%</b>	<b>86.40%</b>	<b>86.50%</b>	<b>88.70%</b>	<b>91.60%</b>
						<b>64.4</b>	<b>62.8</b>	<b>63.1</b>	<b>62.8</b>	<b>65.7</b>	<b>70.3</b>
<b>Secondary 1<sup>st</sup> cycle</b>											
Number of students	20,493	20,168	23,633	28,796	30,497	34,455	37,449	41,253	45,644	46,994	49,139
Population aged 12-14	138,466	137,573	149,360	167,327	173,008	178,412	183,362	187,270	187,788	193,673	200,745
Enrolment ratio (%)	<b>14.80%</b>	<b>14.70%</b>	<b>15.80%</b>	<b>17.20%</b>	<b>17.60%</b>	<b>19.30%</b>	<b>20.40%</b>	<b>22.00%</b>	<b>24.30%</b>	<b>24.30%</b>	<b>24.50%</b>
<b>Secondary 2<sup>nd</sup> cycle</b>											
Number of students	12,655	15,053	16,514	15,643	19,315	20,312	22,620	22,482	29,098	29,843	32,139
Population aged 15-17	110,043	122,624	130,716	147,560	153,268	159,609	165,459	171,129	176,528	181,490	185,404
Enrolment ratio (%)	<b>11.50%</b>	<b>12.30%</b>	<b>12.60%</b>	<b>10.60%</b>	<b>12.60%</b>	<b>12.70%</b>	<b>13.70%</b>	<b>13.10%</b>	<b>16.50%</b>	<b>16.40%</b>	<b>17.30%</b>
<b>Technical and vocational</b>											
Number of students	1,107	860	1,088	1,414	1,448	1,590	1,682	1,871	1,916	1,893	1,786
Population aged 15-17	103,689	115,153	121,408	134,580	140,268	146,269	152,319	152,319	152,319	152,319	152,319
Enrolment ratio (%)	<b>1.10%</b>	<b>0.70%</b>	<b>0.90%</b>	<b>1.10%</b>	<b>1.00%</b>	<b>1.10%</b>	<b>1.10%</b>	<b>1.20%</b>	<b>1.30%</b>	<b>1.20%</b>	<b>1.20%</b>
<b>Higher education</b>											
Number of students	5,542	7,527	10,014	10,768	11,619	13,000	12,912	0	0	0	10,844
In Mauritania								9,972	9,033	8,217	8,941
Scholarship holders abroad								2,500	2,079	1,850	
Population aged 18-21	144,889	147,313	154,326	168,640	174,926	182,036	189,741	197,713	205,689	213,551	221,197
Enrolment ratio (%)	<b>3.80%</b>	<b>5.10%</b>	<b>6.50%</b>	<b>6.40%</b>	<b>6.60%</b>	<b>7.10%</b>	<b>6.80%</b>	<b>0.00%</b>	<b>0.00%</b>	<b>0.00%</b>	<b>4.90%</b>

Source: Department of Planning, Cooperation and Statistics school statistics, National Statistics Office (Population projections) population statistics as cited in ADB (2005).

An additional policy tool that can be used to provide appropriate incentives to domestic production is prudent exchange rate policies that avoid significant and sustained real exchange rate overvaluation, given the negative competitive impact that this delivers to domestic enterprises that seek to export. This is a concern in particular in countries like Mauritania that have large natural resource extraction industries and can be subject to the “Dutch disease”. This is an important issue for consideration with the start of oil extraction in 2006.

In the longer term, however, policies to promote and support enterprise development will be constrained by a continued lack of human skills and expertise unless long-term education policies are successfully implemented. In this area, the on-going efforts for educational reform and the expansion of school enrolment are encouraging, and it is clear that significant progress is being made in Mauritania.

## CHAPTER 5 - SECTOR STUDY: STI IN MINING

Mining is Mauritania's main industrial activity and the largest source of Government revenue and foreign exchange, even though its mineral production is relatively small compared to the largest producer countries such as Australia, Brazil, China and the Russian Federation, and its share of world iron ore production has remained close to 1 per cent throughout the past decade. The industry is dominated by iron mining, although in the past two years copper and gold production has begun. Some basic data on iron mining output is presented in table 5.1. The mining of iron ore began to develop on a large scale prior to independence, and has since then become the major source of economic activity in the country. Until recently only iron ore was industrially exploited, even though the country has extensive mineral resources of cobalt, diamonds, gold, phosphates and the world's largest deposits of gypsum. Consequently, the exploration and exploitation of minerals represent an important potential future source of financial resources as well as production and trade diversification (although obviously still within the mineral mining activities) for Mauritania.

This section seeks to evaluate the state of STI capabilities and the effectiveness of the innovation system in the mining industry, the most important economic activity in Mauritania. It finds that STI capabilities geared towards management of mineral resources and the mining industry have improved significantly in recent years. The national mining company has built up significant capabilities and has managed to upgrade technologically over time and innovate through investment in training and skills development. The mining industry innovation system, however, remains weak and could be greatly strengthened through more active policies.

### 5.1 The mining industry in Mauritania

The Mauritanian iron industry is dominated by a single State-owned enterprise (SOE), "Société Nationale Industrielle et Minière" (SNIM). The Mauritanian Government owns 80 per cent of SNIM stock; the rest is held mostly by Persian Gulf investment groups. Most iron mining activities are centred close to the town of Zouérat. Raw materials are transported to the mining district via a 700 km rail line, which transports water and iron ore back to the port facility at Nouahidbou (non-salted water is used as a dust suppressant when loading and off-loading iron). Almost all of SNIM's iron product is shipped to Europe in raw ore or concentrate form. However, SNIM has also begun to explore joint ventures, such as the current partnership with Sphere Investments Limited of Australia. Their flagship project is the Guelb el Aouj iron ore (magnetite) deposit which is currently planned as an open pit mine, with a beneficiation and pelletizing plant to produce high grade Direct Reduction pellets for export using SNIM's railway and port infrastructure. The start of production is forecast for 2011. Sphere has a 50 per cent stake in the Guelb el Aouj Project for funding a Bankable Feasibility Study that was due for completion in October 2007.<sup>26</sup> Pelletizing is an iron ore value-adding process that increases the concentration of iron, reduces transportation requirements, and commands higher prices. Sphere stock is held primarily by Australian corporate and Persian Gulf Government entities.<sup>27</sup> This project is a major attempt to increase

<sup>26</sup> "Guelb el Aouj" Sphere Investments, August 16 2007.

<sup>27</sup> "Sphere Investments Limited" Zawya®. 16 August 2007 <http://www.zawya.com/cm/profile.cfm/cid1006573>.

local value added and revenues from mining, but is subject to important technical challenges in terms of energy and water availability.

**Table 5.1. SNIM production and exports of iron ore, 2000-2005**

Year	Export volume (thousand tons)	Production volume (thousand tons)	Value exported (\$million)	Value produced (\$million)
2000	11,069	11,345	183.6	190.9
2001	10,093	10,302	178.5	182.2
2002	10,460	9,553	183.8	167.9
2003	9,627	9,627	175.3	175.3
2004	11,003	11,003	246.8	246.8
2005	10,639	10,880	389.4	389.3

Source: IMF (2006a).

Mineral exploration locally outside of iron ore has focused on gold, uranium, diamonds, and to some extent base metals. Exploration activity is dominated by foreign mining TNCs, with exploration activities intensifying from 1997, when Government began to aggressively pursue diversification of its mining activities away from iron ore and granted many new exploration licenses. The sharp rise in mineral prices from 2003 onwards led to increased interest by various major and junior exploration and production mining TNCs in exploration in Mauritania. The world's two largest mining companies, BHP Billiton and Rio Tinto, both have subsidiaries in Mauritania undertaking mineral exploration. However, the true extent of local mineral reserves still remains largely unknown.

The Tasiast gold project construction was launched in November 2005 by the local subsidiary of the Canadian Rio Narcea Gold Mines Ltd, Tasiast Mauritanie Limited SA, about 310 km northeast of Nouakchott. The Guelb Moghrein copper and gold open pit mine, known as the Akjoujt mine, is owned and operated by Mauritanian Copper Mines S.A. (MCM), whose majority shareholder is First Quantum Minerals Limited (80 per cent) of Canada. The Cu-Au Akjouit mine transports concentrate product to Nouakchott for export via ship. These mines have begun to produce and have, as noted in section 2.1, begun to make a significant contribution to mineral production, exports, revenues and foreign exchange earnings.

## 5.2 Mining technology

Industrial-scale mining is a capital-intensive economic activity. Mobile mining equipment is among the largest land-based machines. Infrastructure such as port facilities and processing plants, and capital equipment such as conveyor belts, must necessarily be of a sufficiently large scale to process the large volumes of bulk materials to make a profit. Also, due to its nature as a non-renewable resource, global mineral deposits are in general increasingly lower in grade and found deeper underground. This has resulted in most mining equipment and technology focusing on mechanization and economies of scale. For example, the largest surface haul trucks in the 1980s had capacities of 100 tons, whereas the latest haul trucks have capacities of 400 tons and can weigh upwards of 350 tons. All equipment, from blasthole drills, to truck-loading electric cable shovels, has dramatically increased in size. The equipment is now limited by the inherent strength of the materials and from which it is constructed, such as steel (for example, truck frames) and tire design. As these machines

become increasingly more complex to build and maintain, the importance of its operating at peak efficiency is also becoming critical. On-board sensors monitor the health of the equipment and can warn maintenance personnel before a catastrophic failure. GPS-based in-pit management tools are also widely used to increase the productivity of the entire fleet through algorithms that can calculate the most efficient truck allocations.

Key production inputs such as explosives, tires, and chemicals are complex to manufacture. There are few large-scale equipment and input manufacturers, based mainly in the United States, Japan and Australia. Since commodities such as iron, gold, and copper, are traded globally, mining companies must also compete globally and are therefore forced to adapt to the latest technology relatively quickly; otherwise their production costs would increase to a point where they are no longer profitable. There are very few manufacturers of key mining inputs, which for surface mining such as that in Mauritania include: drilling and loading equipment; truck haulage equipment; conveyor equipment; explosives; and GPS-based Technology. There is no reliable African supplier of these types of mining equipment apart from South Africa, which has a long history of mining and relatively advanced production capabilities. Distributors may exist, but none of the development of the technology takes place outside of Canada, Australia, the United States, Japan, or South Africa.

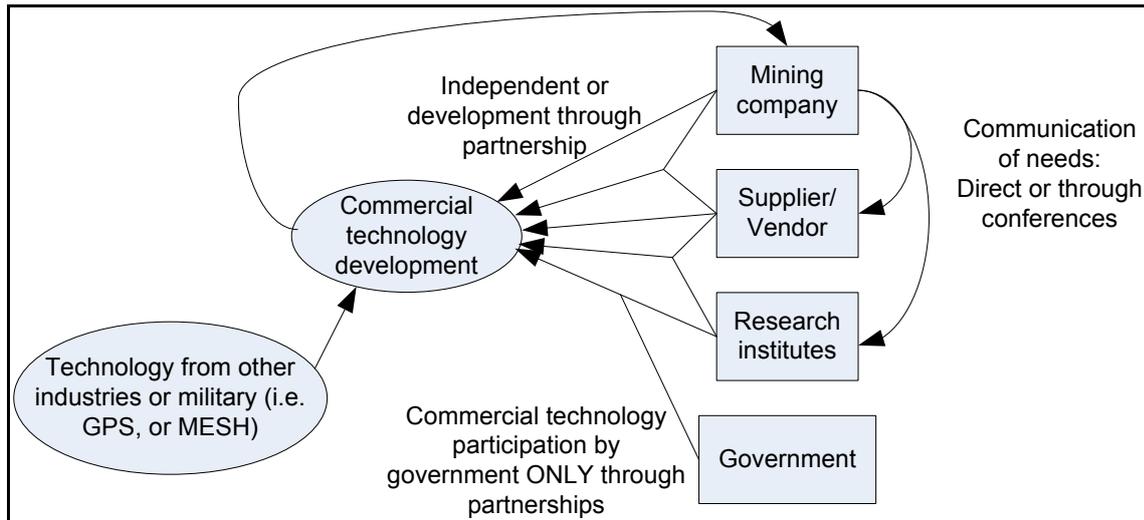
**Technology creation and innovation mechanisms in the global mining industry** - The mining industry has for hundreds of years been one of the most globalized industries. Mining TNCs have historically gone to countries with raw materials, taking with them their technologies and, until recently, all of their engineering expertise. Due to the limited life of mines, dispersion of economic ore bodies throughout the globe, miners and engineers have always brought their know-how to distant countries or regions, bringing the latest equipment and techniques.

There are only a few mechanisms through which technology is developed in mining as illustrated in figure 5.1. First, the need for new technology is identified by mines. The technology is then developed through various stakeholders: in a mining company's internal research groups, research institutes (universities), and by vendors. A common mechanism for the creation of new technologies in mining is to adapt technologies developed in other industries. The primary means of communication between industry and researchers are: direct communications (mining industry personnel visit the institutes or vendors and discuss their needs or visa-versa where institute or vendor personnel visit mines to find out what they need); or attending and presenting at conferences and networking. Each stakeholder in the innovation process that produces new mining technology has different motivations and approaches as is described next.

Major developments such as mechanization, global positioning systems (GPSs), mesh radio systems, and automation have come from enterprises in other areas such as the automotive, electronics, and defence industries. Mining innovators simply adapt these technologies for mining. Consultants and contractors are not represented in figure 5.1, because contract engineering firms never develop new processes or technologies. They are hired to build working process plants and mines. The use of expert consultants is increasing in all mining companies. As the number of skilled technical engineers is decreasing rapidly and most operating companies can no longer permanently employ specialists. They often have expertise in-house that would use technology considered innovative in some countries while representing standard-operating practice in others. SNIM's new Joint Venture with Sphere Investments will use contract engineering services to design and build the new Pellet

Plant. Although considered innovative by Mauritanian standards, the engineering group hired will employ or seek-and-hire consultants experienced with designing pellet or similar plants. As this experience and skill base are not available locally, almost all of the engineering will be completed outside Mauritania. The processes and technologies that are considered standard practice elsewhere (such as in Canada or the United States) could be considered innovations in Mauritania, relative to the technologies currently used.

**Figure 5.1. Illustration of how commercial mining technology is developed**



Source: the authors.

There are few viable purely Government research groups that produce commercial mining technology. Only wealthy countries such as Germany, South Africa and Australia are supporting such research and even in these countries, there is significant pressure for these organizations to become economically self-sustaining. The most common role of Government in supporting mining technology research is to fund universities through mining engineering programmes. However, in most Government-supported programmes, industry partners are required to ensure that the technology developed would be deemed to be of value to industry in the short-to-medium term. Industry also provides regular feedback to university programmes to ensure that the other key product, engineers and geologists, have the training and education necessary to be employable in their operations.

Intellectual property is well respected in mining. The industry is globalized but still relatively small. The author of any significant technical achievement, product, or service is known to most others in that field. Theft of IP would therefore be immediately identified, so few try to operate outside of IP rules. For example, few companies would invest millions of dollars into a new processing technology whose IP for its design is held by another company because the risk of losing those millions of dollars of investment would be too high.

As the mining equipment, deposits, technologies, and systems become increasingly more complex, an equivalent increase in technical skills from personnel within the mining company is necessary. Hence, through education and international experience, Mauritania must likewise develop and constantly upgrade the skills needed to run its iron mining operations.

### 5.3 Mining technology in Mauritania

Operating modern, safe and efficient mines that produce globally traded mine products is technically complex. LDCs such as Mauritania do not generally have the technical or industrial capabilities to supply mining companies with any of the most advanced technology or heavy equipment, or all-but the most basic of production inputs. Artisanal mining is where small-scale miners undertake mining activities with very primitive equipment individually or in small groups, and is not modern and may be unsafe as well as inefficient. Artisanal miners undertake surface or shallow underground mining, normally for high-value products such as gems, diamonds, mineral samples of value to mineral specimen collectors, rare earths, or very high-grade veins of base metals. This type of mining usually results in environmental degradation in the areas being mined and is not generally promoted by central Governments.

Mauritania's mining industry is relatively young and its mineral potential is relatively unknown when compared to other major mining countries, resulting in the country having exclusively surface mines. Surface mining is somewhat less complex than underground mining but typically operates on much higher economies of scale. The Mauritanian mining industry does not differ from industrial-scale mining in other countries in that the source of its mining technology is from the same limited number of vendors available to the global industry. Surface mobile equipment is provided by United States or Japan-based equipment manufacturers. Consulting, computer-based technology, and environmental expertise are derived from Canadian, United States, Australian, or European sources. No mining R&D within Mauritania was observed nor identified. From discussions, it was acknowledged that all technology used in Mauritanian mines are already well-known and used throughout the global mining industry. Technology for minerals exploitation can be subdivided into exploration, mining, and mineral processing.

Exploration technology is characterized by geophysical instruments and geochemical testing used by geologists and prospectors to identify areas of potential economic mineralization. Geological structures such as folds or igneous intrusions are also potential hosts of mineralization. Geological structures are usually first identified using geological maps. The World Bank funded Project for Institutional Reform of the Mining Sector (PRISM) has funded the development of a Geographical Information System (SIGM) which private investors can use to identify prospective exploration claims. SIGM uses modern software and geologic mapping. An Environmental Management Information system (SIGE) has also been established to build competencies in environmental management.

The Tasiast and Akjouit projects are relatively small mining projects, using relatively small equipment when compared to the iron mines of SNIM. Consequently, the use of GPS-based in-pit computer management systems would likely be unnecessary. SNIM has undertaken substantial investments in modernizing its Enterprise System by purchasing and installing SAP (software used to manage inventory, purchasing, and cost analysis) and is also in the midst of acquiring and installing Modular Mining's Dispatch® system (GPS-based in-pit management system).<sup>28</sup> SNIM uses standard mine planning packages (produced by a Canadian mining software firm, Gemcom) for its mining engineering. SAP is a multi-national software company with roots in Germany. Modular Mining is a Tucson, Arizona-based mining

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<sup>28</sup> Based on discussions with SNIM management.

technology company recently purchased by a Japanese heavy equipment manufacturer (Komatsu).

The processing technology used by the three main mining projects in Mauritania are already well-established in the general mining industry; heap leach, flotation, and magnetic separation. With the exception of gold ore, no final metallic product could be produced in Mauritania, since smelting and refining are very complex, energy intensive (consequently beyond the industrial capability of the country), requiring economies of scale unsupportable by current mining output. The lack of available water somewhat complicates these processes. To address this challenge, the project will reportedly use reverse osmosis technology bought from a German firm. The Sphere pelletization project, if and when completed, would likely constitute one of the more complex mineral processing plants in the country. The project will reportedly use reverse osmosis technology bought from a German company to help overcome the scarcity of appropriate water. The engineering design of such mines and plants are typically undertaken by large Canadian, American or Australian engineering firms.

#### **5.4 Education, training and research for the mining industry**

The current cycle of high mineral commodity prices is occurring in the midst of a human resource shortage in mining. There is a global shortage of equipment operators, skilled tradespersons, and engineers. Some sources of this crisis are due to the long-cycle of low commodity prices which caused the closure of many mining trade-schools and engineering departments throughout the world, and impeded the entrance of new employees. Exacerbating this crisis is the demographics in most United States, Canadian, and Australian operations, where the average age of employees in many operations approaches the mid-fifties. The net result of these high commodities, fewer schools, and demographics is the poaching of personnel between companies and often plucking-away the best engineers from developing countries through high salaries and better living conditions in developed countries. This issue is mentioned here, because any initiative to improve the Mauritanian mining industry's innovativeness must also consider the potential loss of human capital to private companies in Mauritania (in the case of talented Government personnel) or overseas. In the case of circulation of personnel within the country, this can be beneficial if the flow of skilled people flows both ways, and among private and State enterprises, thus diffusing skills. Where local skills leave the country completely, the brain drain intensifies, and there may be few or no gains for the domestic economy in the short or medium term if the skills are not recirculated locally or leveraged in some way to achieve some benefit.

A second key issue complicating the development of human capital for improving Mauritanian mining's innovativeness is language. The most common universal language for mining-innovation (conferences, innovative mining companies, vendors, and professional societies) is English. Far less diffusion of technical information is possible, if technical mining personnel speak exclusively French. Spanish is likely the second most important language for real applicable innovation. Consequently, technical personnel who speak only French or Arabic are less likely to be poached but also have generally less access to innovative mining technology (and its effective application).

Several mechanisms are available to Mauritania for the creation of the human capital needed to manage and run the industry and to improve mining innovation capabilities. The lack of good quality and consistent basic level of education provided at primary and secondary levels, as well as technical schools, was mentioned by all interviewees as the most pressing problem limiting the potential creation of human capital for innovation in all fields including mining. This issue is mentioned in this section on mining innovation only because of its importance as a foundation for sustainability for any other initiative. The primary mechanisms recognized by MMP as currently being used in Mauritania for acquiring mining knowledge and skills are<sup>29</sup>: private trade-skills training centres (for example, to train welders, mechanics, pipe-fitters, etc.); SNIM training for trade-skills and management capabilities; the University of Nouakchott; and foreign universities. The education system is currently not generating a mining skills base of adequate quality. Top MMP officials acknowledged that more inter-ministerial communication and policy action are necessary to ensure the higher education system in Mauritania is preparing graduates for the mining industry.

Mining trade people are not normally a source of innovation for mining. In the global mining context, the traditional sources of innovation are: research universities; consulting firms; large mining companies, especially those with research or engineering groups (i.e. Rio Tinto, Freeport McMoRan, BHP Billiton etc.); and technology and equipment vendors (i.e. Caterpillar, Atlas Copco, Komatsu etc.). The mechanisms for transferring knowledge related to the effective use of innovative mining technology and techniques are: hiring consultants; engaging in research with universities or sending promising employees to research universities; buying technology and investing in adequate training; participation in professional societies such as attending technical conferences and networking meetings; and hiring (sometimes poaching) employees from other companies. Few public institutions, such as "Technology and Industrial Property Service" currently play a significant role in the local mining industry. Private sector and SNIM-led activities are at present the most effective in delivering the skills base and technology requirements needed to effectively run the industry.

**The higher education system** - Since no mining engineering training programmes exist within Mauritania (engineering is not taught at the University of Nouakchott), all Mauritania's engineers must be developed in foreign universities. In the past, this has most often been at the Mining and Geological Engineering department at the University of Arizona, in Arizona in the United States, which is useful for several reasons (there are French-speaking professors from Montreal, Canada, there is a large Mauritanian community in Tucson, and Tucson is the surface mining hub of the United States in terms of hardrock surface mining, technology vendors, and mining R&D). However, the lack of local or subregional mining engineering programmes limits the opportunities for local (or subregional) training opportunities. It also promotes a brain drain as qualified engineers are easily employed abroad following their studies.

Universities are often the source for original innovative mining technology that has since been developed into products. For example, Dispatch® and the use of digital imaging for automated fragmentation distribution were invented by professors at the University of Arizona. GPS-based blasthole drill and shovel navigation was initially developed at McGill

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<sup>29</sup> Based on interviews with MMP and PRISM management and personnel.

University (in Montreal, Canada). Since mining is an applied field engineering, theoretical scientific research is of no direct use to the mining industry. There is no non-safety-related Government funding of mining engineering research and negligible levels of support for educational mining engineering programmes in the United States. This has created an environment where the programme must address the specific needs of the industry, namely:

- Produce highly-qualified graduates prepared for immediate employment within industry;
- Engage in highly applied research and development projects useful to industry; and
- Host a variety of professors with expertise the industry needs for consulting and professional education programmes.

Those programmes in the United States that were not able to change to a more applied-model did not survive into this century. Over the past two decades, half the mining engineering programmes in the United States and almost all in Western Europe have ceased to exist. Programmes in Canada, South Africa, Chile, Peru and Australia were provided with more Government support than those in the United States; however, all university systems in these countries have moved toward an industry-centric model rather than a theoretical research and theoretical education model.

The FST at the University of Nouakchott is based on a traditional theoretical model of education and research. Today, scientific and engineering research requires sophisticated computers, equipment, and laboratories. To help improve national prospects, the University of Nouakchott should refocus efforts toward applied science and engineering that could service its national industries. It should consider establishing an engineering faculty given the importance of these skills to the economy currently and in the future. Alternatively, an engineering faculty might be established on a sub-regional basis in collaboration with neighbouring countries in order to overcome deficient resources and inadequate economies of scale. The education system also handicaps local people for mining because of the difficulties in communication with most equipment and technology suppliers as well as foreign mining (and oil) companies with English speaking managers and skilled personnel, for which English language training would greatly help.

## 5.5 Mining firms in Mauritania

**Private mining TNCs active in Mauritania**<sup>30</sup> - Based on discussions with local subsidiaries of private mining TNCs visited, have experienced difficulty in finding and hiring qualified personnel in Mauritania. Organizations in the exploration phase have relatively simple requirements: drivers, radio operators, janitorial services. Companies operating or constructing mines obtain all of their technical (i.e. geologists, mining engineers, mineral processors) or special skills (i.e. pipefitters, heavy equipment mechanics, etc.) personnel from a variety of countries (i.e. European, Canadian, Africans, Central Asians). Attempts are made to train local tradespersons who are already graduates of private trade schools. Yet, it

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<sup>30</sup> Private firms visited included Ashton, a Rio Tinto subsidiary engaged in exploration and Mauritanian Copper Company, a subsidiary of First Quantum Minerals.

was determined that the quality of training at these schools varies widely. These private companies have a tacit unofficial agreement with SNIM not to poach employees.

The subsidiaries currently operating mines in Mauritania are tiny compared to the size of the major mining TNCs currently producing most of the world's globally traded mineral products. Consequently, they do not have the resources or connections to offer the level of support that can be provided by the largest mining companies. However, the companies interviewed indicated that they would voluntarily support educational scholarships as long as the scholarship funds were administered transparently. Other forms of educational and basic equipment support were also suggested, such as donating welding equipment with which welders could practice, provided that such support was a cooperative effort undertaken along with Government and other private enterprises in order to avoid theft or corruption.

The mining TNCs operating mines in Mauritania appear to be adhering to the principles of sustainable mining. These principles include providing health and education services in partnership with the Government as well as promoting economic diversification (ED) in mining communities. Some of these ED initiatives are case studies in local innovation although ED is an integral part of modern mining best practice and is relatively common elsewhere. Discussions with Mauritanian Copper Company (MCC) revealed the following ED initiatives. First, a small amount of the water piped-in from distant mountains for mineral processing was diverted to support a 3800 m<sup>2</sup> greenhouse that was highly productive. Local Mauritians were trained to grow vegetables in the greenhouse and were provided with education on how to sell the produce at a profit and to use part of the profits to re-invest in the greenhouse to gain additional growing capacity. Second, education on how to build and maintain ground-water pumping windmills (as were common in the American plains) was provided to local Mauritians for use in husbandry and for date trees. The design and maintenance of such windmills is sufficiently simple that non-technical people can extend the use of such technology to other communities. Third, solar and wind power energy generation is seen as a more sustainable and cost-effective means of electrical power generation by MCC. Studies are underway on how to use these energy sources for their operations.

Although these initiatives do not help improve the efficiency, cost effectiveness, nor competitiveness of the Mauritanian mining industry, these ED innovations can be studied by MMP personnel, packaged as consulting services, and extended to other desert communities in order to diffuse the practice more widely. These practices have also been a part of the operational approach of SNIM, the National Industrial and Mining Company (Société Nationale Industrielle et Minière).

**SNIM** - SNIM is the largest domestic enterprise in the country, and although owned 78 per cent by the State, it is managed as a pseudo-private corporation. It operates almost as a "State within a State" (as expressed by many stakeholders in Mauritania) since the Government has left the industrial giant to operate with a great degree of independence, acting only as its main shareholder. SNIM contains one of the largest pools of skilled technical human capital in the country, and represents in relative terms a real pole of excellence in terms of technical skills, professional management, investment in staff training and a strong work ethic. The company has Mauritania's largest number of managers, supervisors, technical personnel and tradespeople with a culture of professionalism approaching that of the developed world. It is also the largest source of employment in the industrial sector, with some 3,700 employees.

SNIM operates within a global mining market and therefore must compete with extremely large iron ore TNCs such as CVRD, BHP Billiton, and Rio Tinto. They therefore require a similar level of professionalism as that found in these companies. However, they have higher costs and much lower levels of productivity (in tons of output per man-hour) than their competitors. This Review is not able to determine the degree to which its lower productivity may be due to natural differences from technical elements, or to some other factors such as relative overstaffing (the company being an SOE) or to still other factors. The productivity of manufacturing firms in the country in general is relatively low, so lower productivity in this case is not really unusual. It may be that the general business environment is relatively difficult in the country due to the various constraints to business operations and that productivity levels are bound to be somewhat lower than comparators in more developed countries.

They also face great challenges in terms of developing and then maintaining the technical skills base needed to run the company effectively and in increasing productivity and production capacity. As noted, they also own and operate the Zouérat to Noudibhou railway and their port facilities at the port of Noudibhou, and face major challenges in adequately maintaining these physical infrastructures. As a relatively small mining company, the investments that would be required to maintain these significant infrastructures in top working order are large. Financing large investment needs related to mine maintenance, capital equipment, new technologies and investment in the pelletization project are large additional investments. The pelletization project alone will require a total investment of some \$1.5 billion. During periods of high international iron ore prices such as the current period it is easier for the company to meet these investment requirements due to much higher revenues and profits. Indeed, the company has reportedly become a potential target for acquisition, with interest reportedly expressed in the acquisition of Government's 78 per cent stake by foreign mining and steel TNCs such as Mittal-Arcelor and Rio Tinto early in 2008.

Several years ago, SNIM undertook the development of a comprehensive Vision and Strategy study with input from all senior managers. The plan analyzed both the strength and weaknesses of SNIM, and identifies some of the key changes that would be necessary to help continue making SNIM a viable business. Implementation of the vision and strategy has been pursued through the leadership of the different managing directors (i.e. port and rail, information systems, etc.) even following changes in Managing Director. There has thus been a measure of continuity that is often not seen in public sector administration. A key section in the document dealt with issues of developing the necessary human capital to run an effective mining company in light of the weaknesses in domestic human capital development in technical disciplines. This has been a major challenge for the company, which has pursued a largely autonomous set of training programmes unconnected to the Ministry of Education, the University of Nouakchott or the technical and vocational training institutes. This has meant that linkages to the local economy and local mining innovation system have been reduced, but has been relatively effective as a means to achieving its goal of maintaining a skilled human resource base.

Discussions with the SNIM managers revealed their perception that relatively a few mining engineers are necessary in SNIM operations and they should primarily deal with only mine planning and rock mechanics. With approximately 3,700 employees, and only a few of these being mining engineers, makes SNIM one of the mining companies with large operations yet the lowest incidence of mining engineers on staff. In most successful large-scale mining companies and operations, mining engineers, geologists, and mineral

processors play various technical, managerial, supervisory, and corporate roles. Even in small surface operations. There would be mining engineering positions related to drilling and blasting, dispatch, short-term planning, long-term planning, scheduling/forecasting/budgeting, slope stability/ground control and environment issues.

In addition to these positions, there would also be several junior engineers called “project engineers” engaged in various systems improvement projects such as road design or maintenance studies. The above list is only for mining engineers. There would likely be a similar number of mechanical, electrical, process, and geological engineers engaged in both regular duties such as maintenance planning as well as special projects. Large mining companies remain competitive and innovative by sending their technical personnel, namely engineers, to conferences and technical short-courses. Additional technical staff, if not directly assigned projects and provided freedom to act semi-independently, typically find and execute innovative improvement projects. SNIM therefore has a relatively small technical skills base relative to major mining TNCs, which may limit its technological innovation capabilities. It nevertheless represents a large skills base and a pole of excellence in many respects in the context of the domestic economy.

A key weakness for SNIM’s potential for innovation is a lack of masters or Ph.D. level engineers. Basic engineering education provides students with the tools to be effective engineers. However, contemporary mining technology is more complex and often requires post-graduate education, either in technology certificate programmes or graduate research work. The issue of acquiring more engineers and the most cost-effective technical professional development available are important given that SNIM engineers are ageing and will eventually retire and need to be replaced by new engineers with the requisite skills and experience.

SNIM has addressed the need for continuing training by developing three mechanisms for training of managers and technical staff, none of them linked to local organizations outside SNIM. First, apprenticeship programmes through which heavy-equipment mechanics (such as for locomotives or mining equipment) undergo an apprenticeship process where they work closely with a master tradesman (such as a mechanic or machinist with decades of experience). Second, short-courses abroad for managers and supervisors to engage in specialized training programmes related to management systems (such as Total Quality Management, 6 sigma and leadership training).

Third, on-site or off-site vendor training programmes and resources through which vendors typically undertake on-site or off-site training programmes when large complex equipment or software is purchased as packaged technology agreements. For example, when SAP or GEMCOM (their mine planning package) is purchased and installed, training is provided by the company selling the technology. Similarly, when large equipment such as Caterpillar trucks or P&H electric cable shovels are purchased, these companies provide training to the heavy-duty mechanics on how to maintain the equipment and use the electronic diagnostic technology embedded in the equipment. In this way the tacit knowledge needed to run and maintain key foreign technologies are transferred. It appears that the skills and knowledge base of the engineers and technicians at SNIM are adequate to ensure absorption of these technologies, although the true level of mastery of them is difficult to judge. It is also not clear whether any adaptation to foreign technologies used by SNIM were required for their operation in Mauritania. In addition to these training mechanisms, SNIM has also investigated the possibilities for continuing professional development either through

establishing virtual conferences or by using the new polytechnic institute that is under discussion (see chapter 3), should it finally be established. The virtual conferences are online classes offered by a mining organization based in Canada.

In addition to its mining activities and related infrastructure, SNIM has expanded vertically into the production and maintenance of some of the basic machinery inputs required for their operations. Vertical integration is the norm for most large iron ore producers, so them being closely involved in inputs, processing and related infrastructure is not unusual. They have also expanded horizontally into other business activities such as hotels and restaurants, which are not directly related to their mining operations, although the facilities are in Nouadhibou nearby the company's headquarters. The logic for this is less clear, although the facilities certainly provide a convenient means of lodging visiting staff, consultants, etc.

SNIM has over its decades of experience in mining and its investment in continuing training developed significant STI capabilities. Operating a large, relatively modern mining operation and competing, if indirectly (being an SOE and not a private enterprise), with foreign mining TNCs, has required substantial investment in skills and STI capabilities, and periodic upgrading of technology through technology transfer from abroad. These technologies appear to have been absorbed to a relatively high degree, although this is difficult to judge accurately. Introduction of these technologies have required organizational innovations to make integration into the company effective. Today, SNIM has the largest and most developed professional workforce of engineers, managers, project managers, supervisors, in all of Mauritania operating at level close to international norms. It would be ideal for the country to create effective ways to leverage its pool of expertise for the benefit of the economy more widely so that it acts as a pole of excellence. Currently, its role in the mining innovation system is very weak. SNIM has very few real information, knowledge or business linkages with Government, domestic education institutions, mining TNCs operating in Mauritania or the private sector more broadly. It should play a more central role in the mining innovation system.

## **5.6 Intermediate organizations: PRISM<sup>31</sup>**

The Ministry of Mines and Petroleum (MMP) is responsible for both mining and oil. The mining division's role is to administer and promote the mining industry within Mauritania. The proper management of a national mining industry requires: (a) a professional processing of claims, permit application, taxes and fees; (b) prospecting and exploration aid in the form of geologic maps; and (c) to help insulate SNIM from excessive pressure to use it as a source of revenue for the public sector. To support its burgeoning private mining industry, Government created PRISM with World Bank support. MMP acts as a support mechanism for mining industry demands by functioning as an intermediary between the mining companies and Government, especially in communicating their needs for various Government services. For example, when a list of educational needs was identified by the industry, the needs were first communicated to the MMP, who then communicated the requests to the Ministry of Education.

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<sup>31</sup> The information in this section is from interviews with MMP and PRISM management and personnel, including the environment, geology and claims (cadastre) groups of PRISM.

The creation of PRISM is a good example of hiring consultants as a means of transferring knowledge. PRISM is a World Bank-funded project, whose first phase started in the 1990s and ended in 2004. Phase II started in 2004 and is scheduled to finish in 2008. PRISM is largely focused on creating the Government institutions which facilitate and attract responsible mining investment and allow effective management of the mining industry. The PRISM group is clearly well-educated and highly motivated young professionals that if retained successfully, can remain the core of a highly effective knowledge centre for mining. The technology and techniques applied in this group would not be considered innovative in the global mining context but are likely to be innovative for Mauritania. The different groups within PRISM are responsible for: processing and administering claims, taxes, and fees; maintaining and enhancing a geological map for the country; and cooperating with private mining companies and SNIM to adhere to the practices of sustainable mining (ensuring that mining activities address the relevant environmental and social issues).

In terms of innovation or skills transfer, it is similar to an apprenticeship programme. For example, foreign geological mapping experts (consultants) were used to initially create the geological map. Mauritanian interns or assistants were assigned to these consultants. An apprenticeship process was written into the contracts so that some of the skills and knowledge would be transferred to the Mauritanian apprentice. This appeared to have been quite successful as the PRISM personnel appear to be competent (as well as multi-gendered). The Mauritanian participants are paid by the World Bank at rates much higher than traditional Government bureaucrats thereby attracting high-quality workers. Some were attracted from the ministry of mines (the forerunner to MMP), others from SNIM, while others still were education at foreign institutions. They were initially selected for appropriate backgrounds (i.e. geologists, geo-statisticians or ecologists) yet are also being allowed to pursue further higher education in foreign universities.

Retention of these highly trained specialists will be challenging given the current skill shortage in the global mining industry discussed above. Keeping the PRISM personnel in a quasi-government agency, and thereby allowing for salaries higher than allowed for under traditional Government salary scales, would likely be the only means of retaining such personnel. There is no mechanism currently to divert any of the mining taxes or fees back into supporting such an agency. All money goes directly into the national treasury. Therefore the "agency" would need to be semi-autonomous from the Government, including its funding mechanism, in order to attract and pay their employees at a level such that technical positions are filled by adequately qualified personnel and to isolate the agency from undue political influence.

The feedback from both private and State-owned industry with respect to the mining department of MMP and PRISM was largely positive. A clearer and more streamlined process for adherence to regulations and fees is both requested from industry and acknowledged by PRISM personnel as an area in need of attention.

### **5.7 Framework conditions for mining in the national system of innovation**

**ICTs** - Modern mining operations have become as reliant on interconnected information systems as have most other modern businesses. The Internet network within Mauritania is very limited. Due to the inconsistent national communications service, SNIM must

communicate via satellite between Zourate and Nouahidbou, and are therefore limited to a 1 MB/s connection. The connection to outside the country is limited to 512KB/s. This is a very low bandwidth, considering the demands of the new SAP system or even basic email for a large company. According to SNIM, the university graduates in IT are also unprepared for the networking needs of the company. An example of the impact of this lack of connectivity is the train traffic management. A single rail line connects Zourate with Nouahidbou. In most vertically-integrated iron mining organizations (such as CVRD's operations in Brazil), a GPS-based and wireless dispatch system can control train movements to maximize productivity through predictive (linear, integer, and goal programming) algorithms and centralized control. This is not the case for SNIM.

Technology and heavy machinery vendor support is also very limited for Mauritania. The country's mining industry is too small to support local sales or support offices. The closest support for mining equipment and technology is either from South Africa or the United States. Equipment supplier's services are also far better for English-speaking clients than for exclusively French-speaking people. The very limited internet bandwidth makes remote support unviable. There must be faster improvement in the level of inter-connectivity in the country and in Internet availability if the mining industry is to function competitively.

**Adherence to sustainable mining practices in Mauritania** - Steel and consequently iron ore production has very strict quality control standards. Steel manufacturers often require their suppliers to undergo ISO 9000 certification and ISO 14000 certification. ISO 9000 is a family of standards for quality management systems maintained by the International Organization for Standardization (ISO). The ISO 14000 environmental management standards exist to help organizations minimize how their operations negatively affect the environment (cause adverse changes to air, water, or land), comply with applicable laws, regulations, and other environmentally oriented requirements, and continually improve on the above. Since SNIM sells to manufacturers in Europe, they must also adhere to global sustainable mining practices as can be exercised in the Mauritanian context. For example, in 1997 the PRISM project undertook economic diversification projects and community awareness programmes along with SNIM.<sup>32</sup> The same environmental group at PRISM had also worked with the First Quantum Minerals Cu mine in determining the means by which its concentrate should be transported to the port (closed concentrate containers hauled by truck). As a quasi-government agency (its final status is still unknown), PRISM is working cooperatively with companies, using well educated Mauritians to find agreeable solutions that adhere to the tenets of sustainable mining practices. For the past two decades, the mining industry has undergone an environmental and social renaissance. Environmental science pertaining to mine reclamation and pollutants is sufficiently mature to make engineered solutions available to address and mitigate most environmental issues.

**Government policies to promote STI capabilities in mining in Mauritania** - To achieve a high level of innovative capability in the mining industry, cooperation is needed between Government, State-owned and private businesses, professional societies, technology vendors, and institutions of higher-learning (both foreign and domestic). The innovation system has to function at a minimal level of effectiveness. Government needs to implement specific policies to promote the development of STI capabilities and strengthen the linkages among the key actors in the system. The main explicit Government policies directly aimed at

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<sup>32</sup> Based on discussions with the environmental group within PRISM.

mining industry development are the support to PRISM and the development of a mining code that governs the legal and regulatory framework for mining investment.

The PRISM programme has been very effective in building knowledge, skills and STI capabilities and enabling and encouraging innovation in management of the industry. The development of capabilities through the PRISM programme allows the MMP to effectively manage the mining industry by administering and monitoring mineral resources and mining activities. This is perhaps the most important aspect of STI capabilities in the industry as effective public sector management of mineral resources is absolutely critical for sustainable mining development, and for sustainable economic development of the country as a whole. The PRISM programme is, however, vulnerable to a discontinuation of funding, which needs to be addressed to ensure its continuity.

The second major set of Government efforts has been directed at creating an appropriate mining code (which governs the legal and regulatory framework) and in promoting foreign investment in mineral exploration and production. The mining code of June 1999 (and its implementing laws), which has reportedly been judged as providing a sound legal and regulatory framework for mining investment (World Bank, 2006: 26), is being revised. The law guarantees, among other things, fiscal stability for investments. Whether the law or its revised version is too favourable to investors is difficult to judge. The code has nevertheless been seen as generally favourable by mining TNCs and has promoted exploration by them (high mineral prices between 2003 and 2008 presumably also played a strong role in encouraging exploration). The mining code has little influence on the incentives for building STI capabilities. The spillovers that might occur from the entry of foreign mining TNCs appear to have been very limited in nature. Linkages to the local economy through local suppliers appear to be marginal due to the limited local inputs used in the industry (it is very capital and technology intensive, and the equipment and technology are not produced locally). Spillovers through hiring of local labour and turnover through labour mobility also appears to be limited in skill intensive technical positions because of a scarcity of skilled local labour and recourse to relatively large scale use of foreign skilled labour by private mining TNCs.

MMP officials expressed a willingness to encourage mining TNCs operating locally to employ innovative techniques and share such techniques, but there do not appear to be any actual Government policies implemented. Similarly, initiatives to help improve the University's faculty of science and technology (FST) delivery of higher quality, more practical education tailored to the mining industry through closer cooperation between the ministries involved (MMP and the Ministry of National Education) and the FST have apparently been discussed, but no actual policy result is evident.

### **5.8 Summary and recommendations**

The most important challenges in the industry for Government are the effective and sustainable management of the industry (in terms of the rate of exploitation and the potential environmental and social impacts), ensuring the effectiveness of the State-owned mining company (SNIM) in iron ore mining and increasing the benefits that can be harnessed by the economy in terms of value added locally and linkages to the broader economy. Prudent investment of mining revenues is of course also imperative for promoting economic growth and development.

Substantial progress has been made in improving the resource management capabilities of the public sector. SNIM has managed relatively well, although it has faced, and continues to face, important challenges with regard to building its human capital base, increasing productivity levels and raising production capacity, and maintaining adequately the elements of physical infrastructure that they own and operate (notably the railway lines and train used to transport iron ore). It remains a major challenge to increase value added in mining and to develop backward linkages to the domestic economy. The potential for backward linkages is limited by the enclave and capital intensive nature of mining (as with oil exploration and production).

The industry is subject to many of the constraints to business operations in the country more general, including in particular deficient infrastructure and the weak human capital base. Public sector infrastructure investment directly supporting the mining industry is very limited, and erratic power supply, limited water availability and lack of paved roads are key infrastructure constraints to all companies in the local mining industry (World Bank, 2006). SNIM owns and manages its own infrastructure (rail, train, port, employee housing, etc.) and the two operating private mines only use the national road network. National electrical, telecommunications and water services are too inconsistent to be relied on for regular operations.

STI capabilities are much stronger in mining than in oil due to the long history of mining in Mauritania and the substantial investment that has been made over time in building the knowledge and skills needed for the industry. In terms of public sector administration skills and capabilities needed for sustainable management of mining, a group of highly-trained and professional staff have been developed, notably those supported by the PRISM programme with World Bank support. Ensuring that PRISM retains them is important for the proper functioning of the industry. World Bank funding for PRISM at current levels is unlikely to be sustainable into perpetuity, and a more sustainable, self-funding mechanism, may be needed. One possibility is to establish a new mining agency, with a degree of independence from governmental pay-scales and funded in part through a percentage of the revenues earned through mineral exploration, construction, and exploitation

In terms of mining companies, SNIM is relatively small relative to large international mining companies, but is professionally managed and operates close to international standards. It therefore represents an important pool of skills in the country. SNIM may not currently have adequate human capital resources needed for significant technological innovation from their own effort, but appears to have absorbed well enough the foreign technologies that it has acquired. The other mining companies are all foreign and are professionally managed. For SNIM, there is a need to ensure that they are able to replace an ageing skills base that will be eroded over time as their most experienced staff retire. This is important as there is a widely recognized lack of adequately trained engineers in the country. The national education system needs to be geared towards producing an adequate supply of qualified mining engineers and other technical people needed in the industry.

The major issues in STI capabilities are maintaining the skills and knowledge that have been developed, and being sure that they can be replaced over time. The education system currently does not generate the skills required. To achieve this, it is likely that teaching and research at the University of Nouakchott will have to be reoriented more towards practical and applied areas and away from a highly theoretical bias. The university's

faculty of science and technology (FST) should aim to ensure that the graduates being produced are employable upon graduation. SNIM could be encouraged to maintain regular collaboration with the University, and students engaged in mining-related fields should have educational summer field experiences at the mines themselves. The Mauritanian Government might consider supporting the creation of a mining engineering programme at the University of Nouakchott. Summer training classes or practical short courses might be held at the University, taught by SNIM mining engineers with substantial experience. In any case, there should be greater collaboration between industry, the university and Government on the kinds of training required to sustain the industry. The options for cooperation sub-regionally or regionally within Africa should also be considered.

The culture of universities is notoriously difficult to alter, especially at universities where professors are tenured or approaching retirement. A key performance metric for the university, and especially the FST, might be the number of graduates who gain employment in their chosen field upon or soon after graduation. A key mechanism for changing the system should include seeking input from industry on the skills needed.

In terms of improving the NSI and promoting the development of STI capabilities, there appears to be scope for more active use of explicit public policies beyond support for the PRISM programme. Policies might be used to promote greater spillovers from foreign mining companies by encouraging collaboration with local companies and supporting local companies in upgrading their skills and quality standards to become suppliers to mining companies. The industry representatives interviewed indicated an interest in participating and cooperating with the Government in programmes that support technical education and innovation. However, they do not currently have the incentives to actually do so.



## CHAPTER 6 - SECTOR STUDY: STI IN OIL

Oil production in Mauritania is very recent, beginning in 2006. The production volumes involved are small by international standards, but for Mauritania the impact has been large in terms of increased national output, Government revenues and foreign exchange earnings. The main challenge is to build as quickly as possible the necessary capabilities to manage the oil resources and industry in a sustainable and beneficial manner that avoids the negative outcomes associated with oil production in some other developing countries that have experienced a “resource curse” related to oil production. Many of the issues found in the mining industry hold for the oil industry as well, but there is much less experience and far weaker national capabilities in the oil industry. On the other hand, infrastructure constraints are much less of a constraint than for mining, and it is not certain whether the production life of oil will be very long: this raises the question of how much effort should be expended on trying to develop long term indigenous capabilities for the oil industry. There may be an argument that policy should concentrate on using the oil rents to build other non-oil activities. However, this Review assumes that the need to build human capital and STI capabilities in the oil industry remain a national objective, in keeping with current Government policy in Mauritania.

### 6.1 Oil in Mauritania

Speculative oil exploration activities have been carried out in Mauritania by foreign oil TNCs since 1960. From 1960 to 1992 oil companies from the United States were active in exploration, but they gradually withdrew after what was considered at the time to be unpromising findings following a series of dry oil wells. In 1999 the Government decided to launch a major oil exploration programme and in 2001 began issuing licenses to various foreign oil TNCs to explore for oil. Interest by the international oil companies (IOCs) in exploration in Mauritania was revived, in part due to more attractive Government policies but also because of higher prices and new technologies making deeper offshore operations feasible. Many of these licenses were issued to mid-sized and smaller independent oil companies, although some larger TNCs have entered since then. Oil was first discovered in June 2001 in the Chinguetti-1 offshore oil field 800 metres below water by an exploration consortium led by the Australian oil TNC, Woodside Petroleum (through its local subsidiary, Woodside Mauritania), who originally owned a 35 per cent share in the field and was the operating partner along with several other partners (including Agip, Fusion Oil and Gas and Hardman Resources).

Since 2001 a number of other foreign oil and gas TNCs have taken part at some point in time in some exploration blocks. They include Woodside Petroleum Limited, Woodside Energy Limited, Agip, Fusion Oil & Gas, Hardman Resources, Total, Gaz de France, Dana Petroleum, Roc Oil, Eni, BG Group, Petronas, Premier Oil, Tullow Oil, Sterling energy, Baraka petroleum, China National Petroleum Corporation (CNPC), the peak group, Kuwait Foreign Exploration Company (KUFPEC) and RussNeft. Over the years, some of them have dropped out of exploration in the country, including Woodside themselves who finally sold all their Mauritanian assets to Petronas in September 2007 following a dispute over Woodside’s contract in February 2006 (which was settled in April 2006) with the Government of Colonel Mohamed Vall that had come to power in August 2005.

A number of different fields have been found to contain valuable hydrocarbon reserves. Chinguetti, Tiof and Tevet were identified to have significant reserves of offshore oil, while major gas reserves were found in the field of Banda. Production of crude oil started with the commercial development of the Chinguetti field by Woodside Petroleum in February 2006. Production capacity reached a peak of 75,000 barrels per day (b/d) initially, but technical problems led to a decline of output towards the end of the year, reaching a level of 22,000 b/d and gradually falling further afterwards. The expected life of the Chinguetti field is from 7 to 10 years, depending on levels of production, which are expected to experience a natural decline over the years.

Chinguetti has so far been the only commercially exploited field. Estimates about the potential capacity of the Tiof and Tevet vary widely and will require further field surveys. Woodside, however, is exploring the commercial viability of Tiof to ensure steady production in years to come. The British company BG had also expressed its interest in conducting exploration drillings at the field of Banda with the main objective of developing liquefied gas projects in the future. Unfortunately, in 2007 BG withdrew completely from this project.

Despite an initial promising future for the Mauritanian petroleum industry, some difficulties have already emerged. In 2007 a number of wells that had been thought to be of significant value turned out to be of poor quality. For example, CNPC and Baraka, its partner, stopped exploration efforts in some wells while British Gas Company sold all its assets in Mauritania to the Kuwait Foreign Exploration Company. As noted, Woodside also finally sold out to Petronas. Still, the production of crude oil represents a huge opportunity for Mauritania to increase economic growth, Government revenues and foreign exchange earnings, and finance investments in infrastructure, education, health and other areas that will lead to faster poverty reduction, improved living standards and economic development.

**Potential oil reserves and revenues** - Mauritania has three sedimentary basins of interest to oil companies.

- (a) Coastal on and offshore, which has a number of exploration contracts. As yet there has been no exploration of the ultra deep offshore, where the costs are enormous;
- (b) The Taoudeni Basin, which is the largest sedimentary basin in Africa of which two-thirds is in Mauritania, has seen limited exploration. Exploration began in 1958 and between 1972 and 1974 Texaco and Agip made two discoveries. However, between 1974 and 2002 exploration activities stopped because of the Western Saharan dispute although companies have more recently become interested again and three exploration contracts have been signed. Here the technology is simpler because of its onshore location and the costs are much less;
- (c) The Tindouf Basin borders Algeria and Morocco where there has been no exploration activity until now.

It is difficult to forecast the likely size of oil reserves and the number of years of exploitation, although this information would have an influence on the degree of investment that would be appropriate in terms of building the capabilities and the linkages that may be possible in the industry. The exploration process is far from complete and may yield further oil or gas discoveries. The World Bank (World Bank, 2006) presented two scenarios, a base case and a high case that underpin their revenue projections. The base case that includes only Chinguetti, Tiof (now called Walata) and Tevet reaches a plateau of 75,000 b/d in 2013,

which then begins a steep decline after four years. The high case adds other “yet to be found” fields which produces a peak of 165,000 b/d in 2015. However, the production profile will be a function of the investment levels in exploration, development and production and this depends very much upon how the Government behaves and how it continues to organize the sector. The implication of both scenarios is that Mauritania may have only a few years of significant oil production, which means that its window of opportunity could be fairly narrow.

The production of oil in Mauritania is entirely dependent upon IOCs operating under production sharing contracts.

## **6.2 Potential for the development of the local private sector**

The impact of oil production on an economy can be classified under three linkages – fiscal, forward and backward linkages (Hirschman, 1958). Fiscal linkages are the revenues that can be captured by Government from production and sale of oil or gas. Forward linkages refer to the provision of oil products or gas to the rest of the economy either as energy or as feedstock. Backward linkages refer to inputs from the domestic economy into the sector in the form of labour or local content in the supply chain.

The fiscal linkages will be a function of the net value of the output and the fiscal terms. The impact of fiscal linkages will be a function of how the subsequent revenues are deployed which will determine the utility or return created. There are three possible choices although they are not mutually exclusive. The first is to spend on consumption. The second is to invest in real investments, which can mean physical capital such as infrastructure, factories and farms but also human capital as in education and health. These investments create a rate of return that can then be consumed, saved or invested building the wealth of the economy. The third option is to invest in financial securities. Frequently this has been done in oil producers by the creation of special Oil Funds. Mauritania has already established such an oil fund.

Given the capital-intensive and highly enclave nature of oil exploration, it is primarily the prudent deployment of oil revenues that is important for promoting economic growth along with economic and social development. In general, more secondary potential benefits are possible through backward linkages, forward linkages, increased employment and transfers and spillovers in terms of skills, knowledge and technology. The growth ideally should be in the non-petroleum sector. Thus, when the oil reserves are depleted (or no longer of any value), something replaces the reserves in the nation’s asset portfolio. This creation of alternative wealth to petroleum reserves constitutes sustainable development.<sup>33</sup> The situation is very similar for mineral mining, although the amount of employment creation may be larger. In both cases, potential environmental costs are an important consideration. In Mauritania, the environmental risk is important because oil exploration and production is offshore and could potentially damage the marine environment and endanger the fishing industry which is very important for the country in terms of both revenues and employment.

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<sup>33</sup> Otherwise, the “sustainable development” of an exhaustible resource becomes an oxymoron. For a detailed discussion of such a concept see Hamilton (2002) and Humphreys et al (2007).

Both forward and backward linkages can be thought of as potentially providing development for the country. The extent to which these linkages develop depends on choices made by the Government. Forward linkages depend upon a number of policy choices. Most obviously is whether the Government is willing to supply at subsidized prices. However, in terms of feedstock for industry, it is also a function of the investment climate that determines downstream developments in petrochemicals, metal smelting and other energy intensive activities. This relates to Government involvement in the sectors and how the incentive system for private investment is structured.

Currently the Mauritanian private sector plays a relatively limited role in the oil industry. As discussed already in other chapters, there are extensive constraints inhibiting private sector development. They are compounded because the private sector has in the past expressed only limited confidence in the Government and given the Government's dominant role in the oil sector, and its organization and control, this may inhibit investment.<sup>34</sup> While the IOCs have been working with local private sector companies in terms of port operations, storage, lifting and loadings, the constraints on the private sector operating efficiently at high rates of productivity makes the IOCs impatient and frustrated with domestic private sector performance.

Oil operations require sophisticated equipment. In a country such as Mauritania with virtually no industrial base this inevitably requires importation on a massive scale. The dramatic increase in equipment imports after 2003 reflects the increase in PSA's signed and the development of Chinguetti. The IOC operators and contractors import this equipment. It will obviously be a long time before such equipment can be produced locally (as opposed to being operated by nationals) and in reality such an option is unrealistic unless Mauritania were to prove a much larger oil and gas province than is currently expected<sup>35</sup>. One option for the Government to promote local content is to regulate for a minimum level of local content. Such a policy for example has been pursued in Nigeria and Iran. There are however problems with such an approach rather than leaving it to the discretion of the operators. First, such legislation leads to efforts to avoid the requirement. For example, in many cases such a legal requirement means foreign companies set up a shell company with a local partner. Thus supplies appear to be "local" when the only "local" dimension is a small office and some paperwork with the majority of the equipment being imported. Second, such a policy, if effective, significantly increases the costs of operations and potentially reduces the attractiveness of investing in the country's oil upstream.

There is scope for the Mauritanian private sector to supply logistics and a number of local private companies have been involved. For example SOGECO, owned 35 per cent by foreign capital and 65 per cent by Mauritanian capital, has been involved in logistics for the oil sector for some time. Their workforce is virtually all Mauritanian and they operate to North Sea standards and certification. They joined with five other Mauritanian companies to create the Groupement De Petrole Mauritanienne (GMLP) in order to deal with projects as a consortium in connection to the development of Chinguetti. Unfortunately disputes arose with

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<sup>34</sup> Ibid.

<sup>35</sup> Such an eventuality is not impossible. For example, Nigeria in recent years has been involved in building offshore rigs and platforms locally (Heum et. al, 2003). However, this in part reflects Nigeria's long history as a major oil producer. Another good example of developing a service industry base is Trinidad and Tobago (Paul, 2005).

Woodside as the field operator and although GMLP no longer bids, it is still together pending litigation with Woodside.

In terms of the oil sector providing energy to fuel the economy, the picture is more optimistic. Oil product consumption is around 500,000 tons per year (t/y), of which some 70 per cent is consumed in Nouakchott. Previously, crude oil was imported from Algeria and refined at a small 1 million t/y topping plant at Nouadhibou. The plant was closed in 1999 when Algeria decided it was no longer profitable to operate. Subsequently it has been used as a storage depot (with a capacity of 300,000 cubic metres (cm)) where imported products are stored and then transported to Nouakchott which has its own storage capacity of 60,000 cm. SOMIR who operates the facility is to undertake a study to re-open the plant as a refinery now that Mauritania has its own crude<sup>36</sup>.

The majority of the consumption is for gas oil (diesel), which has shown the fastest growth reflecting the growing importance of road transport. Gasoline and diesel are distributed in what are now privately owned retail outlets. Prices are set at international levels by the Government plus sales taxes so there is no element of subsidy. As for butane, important for domestic cooking, this is imported in bulk with a number of bottling plants supplying the cylinders. This was undertaken by SOMOGAS as a monopoly but in 2005, following liberalization, Total (France) entered as a supplier<sup>37</sup>.

A potentially very important forward linkage relates to the possibilities of using gas domestically. Recent exploration efforts have led to the discovery of two gas fields (Pelican and Banda) with estimated total reserves of 3 trillion cubic feet (tcf) (MEES, 2006). Also the associated gas being produced in Chinguetti is being reinjected. Mauritania suffers from serious shortages of electricity, and the country experiences frequent blackouts and brownouts and it has been estimated that power cuts lose 10 to 12 per cent of the country's industrial production. At the same time, demand for electricity is growing rapidly, especially in Nouakchott. The Government might consider three options. The first is to encourage international companies to invest in generation and assist with the existing generating capacity that depends upon fuel oil and diesel for fuel. The second is to privatize the generating company (SONELEC) that is responsible for generation and distribution together with the National Transmission Company.

The third option is to use the gas reserves for generation, which is being studied. This could be an extremely effective option given that private investment in generation always favours gas because it allows the option of using combined cycle gas turbine (CCGT) technology. This has the advantage having very high conversion efficiencies<sup>38</sup>, an ability to build plant quickly; within two years with a generating capability after one year. Also small plants are economic. All this gives the private investor a much quicker payback than conventional power stations that makes investment correspondingly more attractive, especially in countries that are seen as politically unstable. An important issue for this option concerns the cost to consumers of electricity. There is the further option of exporting electricity although given the very large distances involved this may prove to be not economic.

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<sup>36</sup> Based on interviews in Nouakchott.

<sup>37</sup> Ibid.

<sup>38</sup> Conventional thermal power plants have conversion efficiencies of around 33 per cent while CCGT has efficiencies of between 60 to 65 per cent.

In terms of backward linkages, the Government can regulate minimum requirements to employ local labour and certain levels of local content. It also can affect the take-up by the local economy of the opportunities offered by backward linkages by virtue of investment in infrastructure and its control of and influence over the incentive system for private sector investment. A major problem facing the development of local content is that relations between the Government and the Mauritanian private sector may not be strong. The Government has in the past been viewed with some degree of suspicion by the Mauritanian private sector, with frequent complaints of excessive bureaucracy and red tape.<sup>39</sup> More dialogue, and actual collaboration through a multi-stakeholder approach to developing an eventual STI strategy, by bringing Government and industry together (along with other key stakeholders), could help to improve relations.

In assessing the ability to develop backward linkages, a major issue is that upstream oil operations, especially offshore in deeper water, are highly complex in terms of capital and engineering requirements. Furthermore, those investing require their inputs sooner rather than later. Because of the capital intensity of the operations, time really is money and most operating companies are in a hurry. This is a serious constraint to developing backward linkages in Mauritania where there are serious shortages of skilled manpower and suitably qualified local companies and the institutional context is also relatively weak. The result is that the local content in Mauritania's oil operations is extremely small. No one has actually tried to establish the amount of local content currently, but rough estimates suggest that it can be no more than one to two per cent of total costs amounting to at most \$5 million.<sup>40</sup>

With regard to job creation, the fact that oil and gas production are extremely capital-intensive activities and require relatively little labour is important. Furthermore, the labour that is required, especially when it comes to offshore operations, is highly skilled. There is little scope for unskilled or indeed semi-skilled workers in offshore oil activity. That said, in many countries the national oil company as part of its "national mission" does employ more workers than would be the case for IOCs (Marcel, 2006).

A major problem facing the petroleum sector in the context of employment and manpower planning is a serious lack of data on the current number and types of workers. Some data are available for individual companies.<sup>41</sup> For example, Woodside in Mauritania in 2005 employed "20 to 30" Mauritanian staff but by 2007 this had risen to 97. SOGECO employed 150. As of May 2007, SMH employed 73, all nationals, while the Ministry of Energy (according to the statistical year book) employed 56 in 2004 compared to 62 in 1997. However, there appears to be no central gathering of this data and thus it is not clear how many workers in total are employed. There is even less data when it comes to job descriptions or skill levels. A project (PRECAST) is underway within the Ministry of Economy and Finance funded by the World Bank (\$13 million over 3 years) as part of a project for public administration reform that may help to improve this data problem. Currently there are two databases for Government employment. One is the payroll database controlled by the Directorate of the Budget. The other is the administrative list controlled by the Directorate of Public Services and the two show major discrepancies. PRECAST is developing a new system based upon a census of public services to collect data on functional needs and current skills and training levels in order to identify skill gaps and then to consider how to fill

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<sup>39</sup> Based on interviews in Nouakchott.

<sup>40</sup> Ibid.

<sup>41</sup> Ibid.

these gaps. However, it was pointed out that this was targeted much less at oil and minerals on the grounds that “they have alternatives”<sup>42</sup>.

Obviously the IOCs have the experience and capability to offer training, technology and physical infrastructure to the Mauritanian oil sector. One avenue to achieve this is to regulate this, requiring it as part of the PSA as is the case for example with the provision of funding for training purposes. A variation on this that is common practice in many countries is to legislate for a minimum percentage for employment of nationals and local content. However, such regulations can be counterproductive as they invite mechanisms to avoid the legislation and they can increase costs making the exploration blocks less attractive.

A better route than legislated local content in terms of hiring of local labour is to create incentives for the companies to provide opportunities. The same applies to provision of inputs and production linkages in general. This can be done either through tax breaks although often the incentive of creating a conducive context in which to operate will also help. Local suppliers and nationals will tend to be lower cost than imports and expatriates, although only if the quality is comparable. A good example has been Woodside’s attempts to help local subcontractors improve their HSE performance since poor HSE presents a threat to the operations. One area that could make a major contribution is to make more use of internships whereby ministry and SMH employees are seconded to the IOCs and subcontractors in order to gain practical “hands-on” experience. A good example of this is BP’s programme “Leaders for the Future” which it runs for Sonatrach under the terms of the In-Salah gas project. This involves annually picking 20 or so young Sonatrach employees and giving them four sessions of training in terms of economic and commercial dimensions of the oil industry – two in Algeria (each of one week) and two in the UK (each of two weeks). However, this should be a two-way process. For example, SMH has no expatriates employed. The idea that an NOC should employ expatriates may at first sight seem strange and certainly this was the reaction in SMH<sup>43</sup>. However, the majority of the most successful NOCs do employ expatriates in order to provide training and experience for their staff, especially in the early days of their operations (Marcel, 2006).

### **6.3 Oil industry technology and the knowledge and skills needed to manage oil resources**

It is tempting when considering “technologies” in terms of oil production to think purely in terms of nuts, bolts, pumps, rigs and engineering. However, when taken in a wider sense to include knowledge applied to planning, design and production as well as management, for oil there are a number of key technologies that are important for oil production. While engineering is obviously important it must also include the institutional context, the scientific basis of exploration, logistics and the financial context in terms of project financing and revenue management. In each of these areas, Mauritania is in need of upgrading.

The institutional context for oil relates to two issues, property rights and the licensing system. Investing in oil production, especially offshore involves huge investments. For

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<sup>42</sup> Ibid.

<sup>43</sup> Ibid.

example, estimates have suggested that the investment costs in Chinguetti including new production wells, infrastructure and new exploratory drilling amounted to \$600 million (MEES Various issues). Private companies are only willing to undertake such investments if they are confident they can secure a return on these investments. For the Government, the goal is to obtain a fair share of the oil rent and other potential benefits that may accrue to the country.

The successful negotiation of oil contracts that satisfy both parties requires in-depth knowledge of the international oil industry, its investment patterns and the different fiscal systems in relation to the prospectivity of the acreage. This is highly specialized knowledge, but must be quickly accessed and absorbed by national policymakers and industry regulators. In Mauritania, as in other new oil producing countries at an early stage of development, this poses a major challenge.

The licensing system is the basis on which the company is given access to acreage. There are many variations on this theme from concessions to joint ventures to production service agreements and to service contracts (Dam, 1976). These issues are complex and require considerable expertise in terms of the construction of the licensing system and how the licenses are actually granted. Considerable knowledge of this kind is therefore needed at the national level to successfully manage the industry.

The scientific basis of oil production relates to understanding the geology and geophysics of the acreage and any discoveries. Since the oil price collapse of 1986 when cost cutting became the main driver for private oil companies, there have been considerable developments in seismic activity and computer based simulations including three and four dimensional seismic. In similar vein, the engineering side of exploration, development and production have also undergone a major revolution since 1986 (Martin, 2000). As an illustration, in 1990, offshore operations could be carried out in 750 metres of water. Today that depth stands at 7000 metres. Operating in such conditions requires sophisticated engineering capabilities. Other new developments include horizontal drilling, coil tube drilling and sub-sea completion to name but a few.

Logistics concern supplying the operations involved in exploration, production and development. It involves procurement, storage and transportation. For onshore operations this is little different from the logistics associated with any operation. However, offshore operations require highly specialized skills since delivery involves either helicopter or specialized vessels. In recent years, the move in the oil industry towards a "just in time" approach to inventory management makes the role of transport even more important. Logistics matter because the very large capital investments require the equipment be operated at maximum capacity and therefore delays in providing inputs can prove extremely expensive. For example, in Mauritania, a recent decision by the Ministry that drilling chemicals be tested in Nouadhibou caused considerable problems since the ordered rig was forced to remain idle until the testing was completed.<sup>44</sup>

In terms of the financial context, "technology" relates to two areas. The first is that of project finance. In recent years, especially as the capital cost of projects has increased enormously, there have been major changes in the way in which oil projects are financed (Stevens, 2007). In particular, new financial instruments have been designed to manage the

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<sup>44</sup> Ibid.

large risk involved in such projects. Again this requires sophisticated knowledge of international financial markets.

The second aspect of finance concerns revenue management. Common sense and economic theory argue that large windfall profits from oil projects should enrich a country and its population. Large inflows of foreign exchange revenue can help to overcome capital shortages and constraints to domestic investment and lead to higher economic growth and accelerated development. However, there is strong evidence that the reverse can be true and that large oil revenues can damage the economic base of a country and aggravate poverty rather than alleviate it, creating a “resource curse” (Stevens and Dietsche, 2008; Humphreys *et al.*, 2007; Collier, 2007). The ability of any Government to manage the revenue inflow and avoid a “resource curse” is crucial and requires an understanding of the macro and micro-economic dimensions of the “curse” and what policies can be employed to avoid it.

The way in which the Government deploys the oil revenues will therefore be key to whether they produce a blessing or a curse for the country. In comparison to other aspects of the oil sector, revenue management issues are well advanced in Mauritania and through help from both the IMF and the World Bank prospects on the surface look promising. As for revenue deployment, establishing the FNRH was a good start in managing the oil revenue and ensuring its inflow would not lead to an attack of “Dutch Disease”. What is needed is a clear strategy for the deployment of these revenues.

**Human capital development for the oil industry** - As with data regarding employment, the information regarding training programmes is disparate and diffuse. In the PSA agreements, clause 12 of the contract deals with the training obligation of the IOC. Thus:

“... from the commencement of the Petroleum Operations, the Contractor shall assure priority employment for Mauritanian personnel and contribute to the training of that personnel in order to allow them access to any position of skilled worker, foreman, executive and manager. For that purpose the Contractor shall establish at the end of each Calendar Year in agreement with the Direction of Mines and Geology a plan for recruiting Mauritanian personnel and a plan for training and improving such personnel in order to achieve progressively greater participation of Mauritanian personnel in the Petroleum Operations. The Contractor shall also contribute to the training and improving of the agents from the Direction of Mines and Geology, in accordance with a plan established in agreement with the Minister at the end of each Calendar Year.”

The budget for this was to be agreed per individual contract as part of the general negotiations. In general the sum averaged between \$100,000–200,000 per year and by 2007 this was claimed to be generating some \$2 million.

In practice, initially this led to the IOC spending the money as it deemed appropriate and then presenting the receipts to the Government as proof of meeting its contractual commitments. In 2005, the system changed. Two new paragraphs were added to clause 12 which required to money to be given for training Ministry staff, the provision of conferences and seminars and the training of locals within the IOC. Also the money went to the Ministry who then disposed of it directly. In the Ministry there is in the organigram a training section

but no one has yet been appointed to direct the section although there is talk of developing a plan for training for the Ministry staff.<sup>45</sup> Clearly far more use of the IOCs could be made in training Mauritanian personnel. In particular, simply providing money through Clause 12 is not enough. Not least because, as developed below, it is clear that the elements that make up the Mauritanian oil sector simply do not have the capacity to translate the funds into improved skill levels. There needs to be a much more explicit and “hands-on” role for the IOCs since this represents a key form of technology transfer. Given the current oil law and model contracts are under review this presents a serious opportunity to secure greater direct involvement in training for the IOCs.

SMH has put training of its personnel as its top priority. It has started to produce annual training plans for its 73 employees most of whom are engineers or masters graduates. In the first year, 2006/07 SMH received \$1 million from the ministry’s training revenue from Clause 12 of which 80 per cent was spent. This year they are expected to receive \$2 million. The money is allocated to three budget lines. The first is seen as money for short-term measures including seminars, distance learning courses and the bringing in of outside experts. The second is medium term to provide three to four month specialist courses abroad. The third is to provide on-the-job training for outsiders working in SMH for three to four month internships. SMH is preparing to hire consultants to produce a 10-year strategic training plan. There was also talk of possibly creating a training institute specifically for the petroleum sector.

There are a number of issues to be resolved with these training programmes. The first is the necessity for English since much of the training is abroad. This is certainly the case when it comes to professional training and certification. Second, once trained, other companies poach the employees. For example, SMH has been involved in providing training for 30 engineers abroad, but several of these quickly moved to other companies once trained. This of course is not necessarily a bad thing if they remain in Mauritania since they are keeping their new skills in country. However, this is not so if they simply do not return, which is common, and contributes to the “brain drain”. Also it raises the question of the incentives for companies, especially in the private sector, to invest in training. Some private sector companies undertake their own training. For example, SOGECO has invested heavily in providing training, working closely with Woodside. However, some enterprises that invested in training reported that once the training had been completed, the workers, using trade union pressure, often made what they termed “excessive demands” for higher wages.

A key weakness with the system is that there is little coordination between the SMH training programme and the Ministry and also little communication as to who is doing what and when. Also there is no attempt to create links between the industry and the University of Nouakchott. In general the University’s curricula are highly theoretical producing graduates with deficient practical skills. In short, the training provided by the University appears to be largely unrelated to the needs of the oil industry. The technical training centres were reported by actors in the industry to be moderately good but still inadequate. It appears that the bulk of their trained people are absorbed by the mining industry.<sup>46</sup>

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<sup>45</sup> Ibid.

<sup>46</sup> Ibid.

The education system in general is therefore deficient and needs considerable improvement. There is an urgent need for cooperation between the private companies and training institutions, both the University and technical centres. The ministry has been considering opening departments in Nouakchott University and the Technical Centres to cover aspects of petroleum subject to their ability to mobilize sufficient funding.<sup>47</sup> In this context there is clearly a case for seeking funding and more general support from the IOCs<sup>48</sup> for oil-related education and training. Ideally, the amount of effort put into developing local programmes of education and training would depend partly on the expected size of the industry, but this will depend upon future discoveries and is not predictable with any accuracy. It might also depend upon the possibilities that may be available for collaboration in training on a sub-regional or regional basis using existing centers outside the country.

Currently, estimates of future labour needs are simply not available because there is no manpower plan for the sector which of itself is a major gap and weakness although there is talk of developing such plans. An example of good practice in such planning and its follow through can be found from the experience of the Azerbaijan International Oil Corporation (AIOC). In this case, an experienced individual drew up a detailed list of expected manpower requirements over the life of the production project in terms of skills and experience. This was then used to identify gaps that needed to be filled. The next stage was to approach Universities and training centres in Baku to discuss with them how these gaps might be filled and what resources would be needed including trainers with a view to considering how AIOC could contribute expertise to assist in the courses.

There are currently two projects aimed specifically at improving the capacity of labour in the petroleum sector. The first is a PRISM project (discussed in the previous chapter) funded by the World Bank with the initial focus on trying to attract private investment into the mining sector. PRISM II explicitly includes the hydrocarbon sector and lists its intentions as being:

- (a) To promote investments in deprived areas of the mining and hydrocarbon sectors;
- (b) To increase fiscal income from the mining and hydrocarbon sector by setting up an adequate institutional structure for the follow-up of operations;
- (c) To increase the economic contribution to local and regional social and economic development; and
- (d) To create and strengthen the Government's institutional and technical capacities in the promotion of mineral and hydrocarbons resources including social and environmental issues of resource development.

The second is a project to build capacity for the oil sector began in October 2003 that was funded by the Islamic Development Bank, the Government of Malaysia and the Government of Mauritania. The project had two strands. The first consisted of three studies - the vocational needs of the sector; the impact of the sector on the Mauritanian economy, and the development of an oil sector strategy. The second strand was a series of training programme held in Malaysia.

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<sup>47</sup> Ibid.

<sup>48</sup> Support goes beyond providing additional funding. For example, in Azerbaijan, the foreign management personnel in the Azerbaijan International Oil Company (AIOC) and their IOC partners are actively involved in helping to teach an MBA course at private universities in Baku.

## 6.4 Infrastructure constraints on oil industry development

As the Mauritanian oil industry is offshore rather than onshore, it is very different from mining in terms of the infrastructure needed to operate efficiently. Therefore, the transport infrastructure in the context of Mauritanian oil is perhaps less relevant than might be imagined. Offshore operations depend upon limited transport infrastructure – the port, supply ships and helicopter facilities. The oil from Chinguetti never comes onshore into Mauritania. It is pumped into a floating production and storage unit – a converted tanker, the Bergesen - from which it is loaded to tanker for export. It is therefore heavily enclaved in nature. However, as indicated earlier, such operations can still involve local content and linkages to the domestic economy. For example the Bergesen operates with 150 Mauritanian nationals and only five expatriates, the nationals being trained by Schenker. If and when oil production increases there may be a need for onshore storage facilities requiring pipeline networks and loading terminals.

## 6.5 The legal and regulatory regime

The legal regime that governs the Mauritanian oil sector is based upon a Petroleum Law of 1988. This was followed in 1994 by the model production-sharing contract that is the starting point for negotiations with individual companies. There are no licensing rounds. Rather acreage is allotted as and when IOCs seek to negotiate agreements. Thus the blocks are allocated on an ad hoc basis. Once the contract has been negotiated and signed by the IOC and the Ministry on behalf of the Government, it goes to Parliament and the Senate for approval and is finally approved into law by the President.<sup>49</sup>

There is general agreement that both the 1988 Law and the 1994 model contract need significant revision and currently work is under way, with collaboration by PRISM, to revamp the whole of the legal regime for petroleum. It is vital that adequate relevant knowledge, skills and STI capabilities be developed at the national level to allow the effective management of the industry.

The production sharing agreements are based upon a model contract produced in 1994. Details are then negotiated on a bilateral basis between the Government (the Ministry and the IOC). Currently the only operating field is Chinguetti that began production in February 2006. The National Oil Company – Societe Mauritanienne des Hydrocarbures (SMH) has a 12 per cent share in Chinguetti and a number of shares in other blocks. The model contract is for three years with options to renew twice although each time 25 per cent of the acreage must be relinquished. The production phase is set at 20 years renewable twice, each for 10 years. The contracts also contain stabilization clauses intended to protect the interests of the IOC. The resultant profit oil accrues to SMH and is sold on their behalf by Vitol, a Rotterdam based oil trading company. In 2004, the Government introduced a new simplified fiscal system.<sup>50</sup>

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<sup>49</sup> Under the old military regime, the process was similar except approval came from the Military Ruling Council and the Military President.

<sup>50</sup> Based on interviews in Nouakchott.

The role of the Ministry of Oil is to regulate the sector. Specifically, it has the potential to control production and is responsible for managing cost oil and production metering. SMH is to deal with operational issues and is funded by its equity oil although the Government in 2005 provided a “starting fund” of \$5 million. In October 2004, the Government exercised its option in the contract to take 12 per cent of Chinguetti at a cost of \$145 million<sup>51</sup>. In 2006, the Government received \$60 million in profit oil of which SMH was allowed to keep \$7 million. In the event that SMH makes an operating profit, it will be subject to a 25 per cent profits tax<sup>52</sup>.

In April 2006, the Government created the National Hydrocarbon Revenue Fund (FNRH). This is an account that centralizes petroleum revenue (World Bank, 2006). It includes the Government’s share via profit oil from the PSAs, corporate income tax and other taxes on oil companies and their subcontractors plus signature bonuses from the PSAs and other bonuses and fees. The resources base for the Fund is defined as “fiscal revenues from exploration, production and sale of crude oil, as well as the return on investment” (World Bank, 2006: p. 37). These resources are invested offshore to insulate the real exchange rate from an attack of “Dutch Disease”. The Fund is managed by the Central Bank and the *Comite Consultatif d’Investissement* (CCI) is to be created to oversee the management. The monitoring of oil revenues and their deployment is to be done by the *Comite National de Suivi des Revenues des Hydrocarbures* (CNSRH). Withdrawals in any year are limited to a ceiling authorized by the budget law. FNRH is seen as having three roles, revenue stabilization, a source of regular income from interest payments and covering the interests of future generations.

## 6.6 Summary and recommendations

As with the mining industry, one of the most important challenges in the oil industry for Government is the effective and sustainable management of the industry (in terms of the rate of exploitation and the potential environmental and social impacts). The prudent investment of the oil revenues is likewise critical. Building the competence and effectiveness of the national oil company (SMH) is also an important objective. Of course, developing backward and forward linkages, additional job creation and knowledge, skill and technology transfer represent additional objectives.

In terms of STI capabilities the petroleum sector is very weak, which is to be expected given that the industry is very young. The industry lacks capacity in all relevant areas of technology. The education base is not improving as quickly as it could, with the University of Nouakchott having few practical linkages to the industry. In fact, there exists a serious disconnect between the education system at all levels and the requirements of the petroleum industry. However, there are some encouraging signs that innovation is taking place in the private sector companies operating in the oil sector in the areas of supply and logistics. This is especially true where there is an element of foreign ownership, as the foreign partner has an economic incentive to try and introduce best practice from abroad in terms of new products, processes and new managerial forms. While this is sporadic and limited in scope, it provides evidence that in the right circumstances innovation in the Mauritanian oil sector is can take place. An important challenge is to increase the positive spillovers from foreign

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<sup>51</sup> This was funded by a loan from Sterling Energy who will receive cost recovery of its investment and a share of the “profit oil” (MEES, 2004).

<sup>52</sup> Based on interviews in Nouakchott.

partners to local enterprises so that the benefits of FDI in terms of knowledge and skill transfers are magnified.

There is a great deal of effort needed to strengthen STI capabilities in the oil industry. Large efforts are already being undertaken to improve oil revenue management skills, which is necessary. A concerted effort is needed to kick-start the process of STI development in the industry more broadly. This would ideally be integrated into a national STI strategy and involve the creation of a strategic plan for the oil industry. In particular, emphasis should be placed upon the role and responsibilities of SMH and how these might develop over a 10-year period. This could be based upon comparisons with other countries' experiences. In developing STI capabilities, the education and training requirements are key issues. However, they imply a need for manpower planning that is in turn related to prospects for the growth of the industry, which is at present uncertain. This represents a major challenge. Nevertheless, a manpower plan for the whole industry needs to be developed, which would identify in detail the number of workers required over the next ten years and their required skill and experience levels. This could then be used to identify gaps and help coordinate training.

To fill the education requirements for the industry, the schools need to improve technical education, and progress is needed in developing capacity at the University of Nouakchott in relevant areas for petroleum both in terms of earth sciences, engineering and technology with a view to offering courses within the existing degree structures and also encouraging relevant research in these areas. In this context, the IOCs could be encouraged to support such developments both financially and in terms of offering technical teaching and research support. In addition, more attention should be paid to the provision of English language training given this is the universal language of the international petroleum industry.

To build the public sector knowledge and skills base quickly and enable effective public administration, SMH could hire a small number of expatriate experienced oilmen on short term contracts to work alongside Mauritians and to pass on to them their knowledge and experience. The Ministry and SMH could create internships with the IOCs for their staff to benefit from practical, hands-on experience in the industry. This could be explicitly written into the revised model contracts.

There also needs to be an institution whose function is to coordinate all training activities in the industry and to then liaise with the university and technical centres to begin the process of developing a training plan for scientific and technological aspects of the petroleum industry.

There is no central archive for the many studies that have been undertaken on the petroleum sector in Mauritania in recent years. The result is that these studies get little or no dissemination and many of those in the sector are unaware of their existence. Furthermore, some of the studies are effectively repeats of what has already been done. At the same time, there needs to be a much greater effort in the collection of statistical data for the petroleum sector and its dissemination. An archive for this – studies and data - is an essential requirement with access for all elements of the sector. The archive for studies could be attached to the institution that coordinates training.

## CHAPTER 7 - CONCLUSIONS AND POLICY RECOMMENDATIONS

Mauritania faces major economic, social and environmental challenges that cannot be successfully addressed without improved STI capabilities, faster technological upgrading and a stronger national system of innovation. The country is currently at a very early stage of technological development and needs to make rapid progress in order to improve local production by using existing knowledge and technologies more intensively. However, the national innovation system and sub-national innovation systems are ineffective and suffer from major shortcomings that create extensive systems failure. The infrastructure and finance needed to support domestic innovation, while under active development, remain problematic and deficient. The ability to access, efficiently use and adapt foreign technologies to local use requires improved STI capabilities in private and public sector enterprises, including farmer-owned enterprises, and the public sector as well as society more broadly. It is natural that domestic capabilities and the NSI are both less strong than in more developed economies with more complex production structures. However, there is an urgent need to upgrade them in an organized manner in order to diversify production, improve productivity and increase local value addition beyond the basic raw material exports of oil, minerals and unprocessed fish that currently dominate the production structure. They are critical for enabling larger knowledge and technology acquisition and correspondingly larger benefits from inward FDI, potential linkages to foreign enterprises active locally and imports of machinery and equipment with embodied technology.

The key concern is that, despite the significant economic and social progress registered since the 1960s, Mauritania is advancing at too slow a rate at present to create a dramatic and sustainable improvement in living standards. Over the past two decades, the country has made large efforts in improving basic education, upgrading key infrastructure, promoting macroeconomic stability and implementing economic reforms to move towards a more market-based economy driven by the private sector. Work has therefore long been underway to establish the basic infrastructure needed to support the development of a stronger NSI. Much has been achieved, particularly in basic education (although much faster improvement in human capital remains key) and in establishing macroeconomic stability. However, the only way for the country to develop more rapidly is to design a realistic national strategy to improve STI capabilities and build a stronger NSI in coordination with other key aspects of its national development strategy related to private sector development policies, education reform and trade and foreign investment policies and the ongoing efforts at improving the physical infrastructure. In other words, the microeconomic reforms currently being pursued must include a focus on building the capabilities that are needed to build a strong productive capacity in agriculture, industry and services sectors in order to take advantage of the improved macroeconomic conditions. This chapter briefly reviews the findings of each chapter of the review then outlines the key issues related to STI that need to be addressed and seeks to provide an idea of what actions might be given highest priority in a national STI strategy.

Currently, STI capabilities are in general very weak in Mauritania, and the NSI is not well developed. This is not necessarily unusual for a country at its stage of economic development. There is an inadequate supply of technically proficient labour to meet the needs of industry and average rates of productivity among firms are very low, particularly in the smallest firms. Most firms invest little in staff training and the general level of mastery of

foreign technologies among firms appears to be low. The mining and oil studies, for example, illustrate the need to improve both STI capabilities and innovation systems in the country. In mining, this is needed to maintain the relatively high standards achieved so far and improve them further. In oil in order to build the capabilities needed to effectively manage the industry in a way that is both sustainable and avoids the worst outcomes from significant oil and mineral deposits that could create a “resource curse” while also creating the knowledge and skills to allow effective regulation of the industry, build local participation in higher skilled occupations and promote the development of linkages to the domestic economy to the extent that this is feasible. In fisheries there appears to be great potential to improve value added through processing activities while promoting the sustainable management of the industry through the application of STI policies. Rural sector development is central to poverty reduction. It appears that support in developing STI capabilities, accessing appropriate technologies and diffusing technologies already being used successfully by some farmers in the country, could all play a role in increasing incomes from agriculture and livestock rearing. Manufacturing remains at a nascent stage of development outside of mining and now oil. The issue of the feasibility of expanding the manufacturing base is key to stimulating industrialization in Mauritania. Outside of mining, there is scope for greatly increased STI capabilities in manufacturing, which will require Government support. Targeted, sector-level policies will be needed to complement any eventual national strategy on STI development.

In terms of the national innovation system, the linkages among the main actors in the NSI are in general deficient and the intensity of knowledge exchange and collaborative relations among private enterprises, public enterprises, the Government ministries, the public research centres, the technical institutes and the University of Nouakchott are so low that the functionality of the NSI is strongly undermined. In addition, the enabling conditions needed to produce a well functioning NSI are also deficient in several respects (specifically, weak human capital, major deficiencies in physical infrastructure and a poorly developed financial system), which represents a handicap to enterprises in general by raising the overall cost of production and making it more difficult to attain international competitiveness. The early stage of financial sector development and severe restrictions on the availability of credit for most microenterprises and SMEs (indeed for the majority of enterprises in Mauritania), represents an especially severe constraint on both enterprise formation and growth compared with other countries that might be considered good comparators (such as neighbouring countries from the Maghreb and sub-Saharan African sub-regions). It therefore represents an important binding constraint to enabling a high rate of domestic investment in the country. Most enterprises have low rates of productivity and relatively low profitability, which limits the possibility of creating high rates of investment through reinvested profits.

Unfortunately, low priority has been accorded to date to building STI capabilities and a strong NSI. This is reflected in the absence of a clear and coherent strategy to build these capabilities, upgrade technologically and improve the functioning of the country’s knowledge systems and NSI. This represents a critical weakness in Mauritania’s current development strategy, which is dependent upon building a dynamic private sector that actively seeks out and meets profitable investment opportunities and thereby stimulates economic activity and job creation. The ability of private enterprises to fill this role is in turn highly dependent upon them creating and deploying entrepreneurial, technological and innovation capabilities. These capabilities are at present deficient. There is also at present little public support in identifying useful technologies (through technology scanning, for example) or in helping firms to access and master them. A strategy is therefore warranted to promote the upgrading of

the country's STI capabilities as a complement to other policy measures that have been designed to improve the country's economic performance and reduce poverty. This point is evident in the lack of visibility and integration of technology and innovation policies in the country's poverty reduction strategy papers (PRSPs) that in effect serve as the basis for their national development plan and is the primary reference document for foreign development assistance. The role of STI policies would seem to warrant appropriate integration into the national development strategy via their inclusion in the PRSP.

**Creating a national strategy on STI** - The combination of deficient enterprise-level STI capabilities, a weak NSI and significant weaknesses in several key elements of its enabling conditions mean that Mauritania faces a major challenge in building its STI capabilities and strengthening its capacity for technological learning and innovation at a speed that would allow faster convergence towards the level of capabilities of the most dynamic economies and an effective technological catch-up process. In order to achieve this there needs to be an organized and sustained effort on the part of Government to actively promote technological upgrading and build STI capabilities in a strategic manner, and to achieve simultaneous progress (or "co-evolution") in several different respects – human capital, STI capabilities, physical infrastructure, as well as the financial system. As no clear strategy or formal institutional arrangements for STI policy exist, there is much to be done.

The first step is for policymakers to realize the importance of upgrading in these respects to the country's development, and to begin discussions on designing a realistic national strategy to improve STI capabilities and build a stronger NSI. Public realization and acknowledgement that a significant problem exists is the most basic step in the process towards progress. Considering potential solutions is the second step. Designing a national STI policy would present the advantage of producing a coherent approach to building STI capabilities that could be translated into a strategy and related plans to work towards. It should identify several things: the types of STI capabilities that are most needed and the key obstacles to improving them; what might be feasible in terms of relieving these constraints given current and potentially available human and financial resources; what the priorities should be for action and over what time frames; what type of sequencing in terms of policy measures would be most appropriate; and, finally, how to monitor implementation and the degree of success in meeting goals and amend the strategy and related plans as might be necessary. This is a demanding process in any country, but nevertheless a necessary one to accelerate progress in Mauritania. This strategy should form part of, and be consistent with, the country's broader national development strategy, and should therefore feature appropriately in its PRSP and related development assistance programmes. The PRSP highlights the role of the private sector as an engine of growth and currently addresses some aspects of STI policy, such as education reform and supporting SME development, but does not adequately integrate a real strategy for improving STI capabilities that is needed to support private sector development.

**Recommendation:** Policymakers should begin discussions with all relevant stakeholders on the need for a national strategy on STI with the aim of designing such a strategy in light of their national priorities and their particular circumstances. The strategy should seek to include a statement of its key objectives and related action plans, with a prioritization of actions and a matching of them to potential funding sources. Policymakers should consider how the strategy would fit into their national development strategy, specifically the PRSP, and what role development assistance (including bilateral and multilateral aid) programmes might play in terms of funding.

**Policy coordination and institutional arrangements** - There has never been a national policy on STI in Mauritania, which is related to the fact that no public body, whether a ministry, ministry department or advisor (or advisory body or council) in Mauritania has ever been mandated to oversee STI. This raises the issue of whether there needs to be some formal mechanism to provide oversight of STI development and what type of institutional arrangement would be best. Establishing a Ministry of STI is a possibility, but has the major disadvantage that it may prove unable to coordinate in an integrated manner the different ministries and public bodies that in reality feed into the NSI and are all important determinants of whether STI policies are ultimately successful in stimulating technological and innovative development. The ministries dealing with trade and industry, education, training, employment, water, energy, ICT, private investment, public administration, health, environment, agriculture, fisheries, mining, oil, artisans, as well as economy and finance, may all have a role to play in implementing successful STI programmes. Inter-ministerial cooperation and improved linkages between Government, industry and knowledge sharing and creating institutions (technical and vocational schools, research institutes and universities) are required for the success of such policies, but the history of such cooperation to date in Mauritania has been very weak. Some sort of STI council or advisor to the head of State with cross-ministerial functions might prove more effective. A key to success would be political support and leadership at the highest possible level combined with support at an operational level among middle and higher management levels within different ministries.

In order to organize discussions on a national STI strategy, appropriate institutional arrangements may be necessary to create a focal point to be responsible for organizing STI-related discussions and leading the design and implementation of any eventual STI strategy that may be designed. The optimal arrangement requires some consideration. The development of an STI strategy would require the coordination of the views and ideas of different Government ministries, among others, as STI policy is cross-cutting in nature. In Mauritania there is currently no Government ministry or department responsible for science and technology or STI more broadly, nor an S&T advisor. As a result, there is a wide degree of freedom in designing institutional arrangements to fit the country's circumstances. Policymakers should consider whether some formal institutional arrangement is appropriate for STI coordination in Mauritania, and what type of arrangement would be optimal. In many countries there is a specific ministry responsible for science and technology issues, while in others there is a national council or national science or S&T advisor to the head of State, but no ministry as such. Other hybrid arrangements may also be possible.

It may also be possible to establish an interim arrangement for the planning and preparation of discussions aimed at designing a strategy, with the institutional arrangements to be decided upon as part of the discussion and planning process. Institutional arrangements might also be designed with the explicit intention to review their effectiveness in delivering the desired outcomes with the clear possibility of revising them based upon the findings of this Review. The aim should be effectiveness in achieving the goal of progressing within a reasonable, clearly stated time frame, on a consultative process leading to the design of such a strategy. An STI Council or advisory board, headed by a national STI advisor, located under the head of State (the office of the President) and given the authority to coordinate across ministries and with other, non-governmental stakeholders (the private sector, research institutes, the University of Nouakchott, technical schools, development partners and others) may be the most effective arrangement for planning the design of a national STI strategy. The formation of an inter-ministerial working group chaired by the

national STI advisor might be considered as a means to creating effective channels of communication and achieving the high degree of collaboration needed across and within ministries. Representatives of key non-governmental stakeholders might also be represented to promote the development of linkages and information and knowledge sharing among them (and achieve a true multi-stakeholder dialogue), the lack of which has been identified by this Review as an important obstacle to economic progress at present. Without some formal institutional structure, it would likely prove difficult to ensure either that effective follow-up is made to any decision to create a national strategy or that effective processes are pursued to gain Government-wide and non-governmental input into the process of designing the strategy.

The institutional body on STI would require political support from the highest levels because of the need for active inter-ministerial collaboration – which would represent a significant change from traditional practices in Mauritania’s public administration – and to ensure that an STI strategy featured in the country’s national development plans and PRSP and push for increased donor support for STI initiatives. Financing will remain a particularly binding constraint to the policies and programmes that can be implemented in the country. Political support and political will in the design and implementation of a national STI strategy, as with a national development plan more broadly, are key to success in creating a dynamic economy. An STI Council or advisory board with a national STI advisor reporting directly to the head of State (the President) could be an effective way of promoting such support.

**Recommendation:** Formal institutional arrangements for first discussing, then designing and afterwards implementing and evaluating, a national STI strategy, should be agreed. The specific arrangements would need to take into account existing Government structures, but should aim to create the most effective institutional arrangement possible for ensuring collaboration by stakeholders. The possibility of later revisiting the institutional arrangements as appropriate to improve them - following a review of their effectiveness - should be recognized from the start. The institutional arrangements selected should seek to ensure high level political leadership and include both inter-ministerial and key non-governmental stakeholder participation so that a real multi-stakeholder approach is achieved.

**Some suggestions on prioritization of areas for action** - Three issues are immediately relevant and impact directly upon the development of a national STI strategy and how to proceed. First, the relative scarcity of resources – both financial and human capital, including public administration capabilities. Second, the need to establish the basic infrastructure and framework conditions on which strong capabilities and a well functioning NSI are based is a key constraint not faced by more advanced economies. Third, the breadth of constraints to faster development means that attention must be simultaneously focused on other key issues related to development strategy. All three considerations place real constraints to what may be realistically achievable in the short- to medium-term. A targeted and realistic approach focusing relatively heavily at the start on the need to establish the basic requirements needed to develop dynamic STI capabilities in the medium and longer term may be appropriate.

As noted in United Nations (2005) and UNCTAD (2007a), the ability to design and successfully implement an STI policy requires civil servants with an adequate capacity for policy analysis in the areas relevant to STI policies. Strengthening institutional capabilities for

effective public administration (including planning, implementation, monitoring and evaluation of programmes) would in itself be an important element in building STI capabilities in Mauritania. Developing such capabilities are also necessary for effective public policy design and implementation more broadly, including all areas of Government activity that have a significant impact on society and the economy. This might represent one of the key goals to prioritize for immediate action as part of a national STI strategy. Inter-ministerial collaboration on STI policies and training programmes would help, and would need to be complemented with more industry-specific policies in ministries dealing with more specialized subjects such as mining, oil, health, agriculture and fisheries.

In order to develop strong STI capabilities, further human capital development will be an important goal. Human capital development provides the basis for STI development and should therefore be a major goal through continued education sector reform aimed at improving both the quality and quantity of education opportunities, including improved technical and vocational training. Significant progress has been achieved in improving access to primary education; more effort is needed to improve secondary and higher education and to ensure that the content of curricula are relevant to the country's needs, including in particular the needs of enterprises. Education in technical subjects – science, engineering and mathematics – might be prioritized as areas in need of improvement. Promoting enterprise development and the capabilities needed for successful entrepreneurship is a critical component to strengthening the private sector. Language skills and entrepreneurship and business management skills should therefore be strengthened. Efforts at education system reform are currently underway in this regard, and these should be strongly supported. In terms of higher education, increased collaboration on a sub-regional or regional basis, supplemented as appropriate by bilateral international efforts, might be pursued. This issue requires further, careful consideration. Further consideration is needed on leveraging the Mauritanian diaspora abroad, for technology scanning exercises, for example.

The enabling conditions for STI development represent an additional area that requires priority attention in a national strategy. The physical infrastructure, in particular electricity provision, and the financial system both require targeted attention. Addressing the needs in these areas would be important in a national strategy on STI development.

Beyond these four immediate broad goals – strengthening institutional capabilities for effective public administration in STI policies, human capital development through education reform, and focus on physical infrastructure as well as financial sector development – a national STI strategy should seek to identify what national policies should be used to provide incentives to STI upgrading and to strengthen the effectiveness of the NSI. A number of additional issues have been identified in this Review as obstacles to strengthening STI capabilities and improving the effectiveness of the NSI that should be addressed in a national strategy. These include the following:

- Limited awareness among policymakers of the need for an STI strategy;
- Weak public administration with frequent personnel changes, resulting in lack of institutional memory and policy discontinuity, and insufficient coordination among Government ministries;
- Limited use of policies to encourage and assist enterprises to grow or invest in training, technological upgrading and adoption of new technologies;

- A weak entrepreneurial base that is sustained by lack of business development services and a culture of trading rather than investment in production;
- Limited and uncertain public financing for public R&D, and lack of private sector investment in R&D or training;
- Lack of coordination of public sector training and R&D across Government ministries, PRIs and the University of Nouakchott;
- Deficient role of the University of Nouakchott as a centre of innovation;
- Excessive theoretical (as opposed to applied) focus of research at the University of Nouakchott;
- The need to further reduce bureaucratic obstacles to starting and operating a business enterprise;
- Lack of support to domestic enterprises on the provision of information on available technologies and on the transfer and absorption of foreign technologies;
- The absence of active promotion of domestic quality standards as a means of promoting increased quality of domestic production and encouraging private sector investment in training and improved technologies; and
- Lack of policies to leverage the significant reserve of skilled Mauritanian diaspora abroad for domestic benefit.

The challenges are enormous, but it is vital that a start be made at the earliest opportunity given the cumulative nature of building these capabilities and the high risk of failure in accelerating economic development and improving living standards in the medium- and longer-term in the absence of such an effort.



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