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Educational, Scientific and
Cultural Organization

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SC-2008/WS/22

Printed by Stella srl
Printed in Italy

Science, Technology & Innovation Policy for Lebanon

Comprehensive Document

Preface

Since its establishment in 1962, the National Council of Scientific Research (CNRS) in Lebanon has been the national institution entrusted to advise government and societies on the impact and repercussions of the rapid progress in the application of science and technology; directly through its affiliated research centres, and indirectly through cooperation with academic and other scientific institutions.

In April 2006, the newly formulated five-year Science, Technology and Innovation Policy (STIP) was officially launched in Beirut by the Lebanese Prime Minister H.E. Mr. Fouad Siniora in the presence of the Director-General of the United Nations Educational Scientific and Cultural Organization (UNESCO) H.E. Mr. Koïchiro Matsuura.

STIP sets out to enhance and diversify science, technology and innovation input in economic activities resulting in the creation of high-quality jobs and investment opportunities. It has been prepared by a team of international experts and Lebanese stakeholders in cooperation with the CNRS, UNESCO and the Arab League Educational, Cultural and Scientific Organization (ALECSO). Substantial input has also come from the UN Economic and Social Commission for Western Asia (ESCWA). The CNRS wishes to express its special appreciation to all of the organizations involved for their efforts, commitment and valued contribution.

STIP represents not only a change in the operation of the CNRS itself, but also a change in its relationship with all relevant stakeholders. It is a formulation of a comprehensive vision, linking together identified socio-economic societal needs and qualified human resources capable of finding relevant solutions to respond to these needs. STIP stresses the need for partnerships between all stakeholders in Lebanese society in order to successfully formulate and implement the STIP Plan of Action in all its phases.

In its current state, the implementation plan calls for the CNRS to organize specialized national stakeholder workshops in order to define more focused

priorities and research programs to converge STIP outputs effectively into direct benefits to Lebanese services and productive sectors.

Unfortunately, efforts to implement the STIP have been slowed down due to the catastrophic effects of recent military conflicts. The Lebanese Government has been confronted with the huge task of coping with the impact of this conflict, particularly the rehabilitation of a destroyed infrastructure and the recovery of the economy that came to almost a stand still. For STIP this means awaiting recovery of the Lebanese economy, and government financing allocating the promised 30% of STIP budget.

Nonetheless, the CNRS has been able to gradually implement some of STIP recommendations, namely:

(1) Adopting STIP priorities in its grant research program that finances research at Lebanese universities.
(2) Initiating steps, with the support of UNESCO, leading to the establishment of a Lebanese National Observatory of Science, Technology and Innovation.
(3) Calling on Lebanese universities for the joint establishment of Associated Research Units, as centers of excellence in priority areas defined by STIP.

The CNRS is committed to the implementation of the STIP and is driven by its general directives. The CNRS will continue to implement the priorities of the STIP in an innovative and comprehensive manner to secure credibility and to gain the confidence of all concerned in Lebanon.

Mustafa El Tayeb
Director
Division of Science Policy and
Sustainable Development
UNESCO, Natural Sciences Sector

Mouïn Hamzé
Secretary General
National Council for Scientific
Research, CNRS
Lebanon

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Experts and Contributors

The process of formulating the Science, Technology and Innovation Policy (STIP) for Lebanon was undertaken at the National Council for Scientific Research (CNRS), starting in 2002, after an initiative sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The process received partial financial support from the Arab League Educational, Cultural and Scientific Organization (ALECSO), as well as scientific and technical contributions from the Economic and Social Commission for Western Asia (ESCWA). The CNRS covered about 75% of the project expenses.

The STIP preparation process was carried out through a wide participatory and consultative approach, directly involving prominent Lebanese personalities in the scientific community, in addition to international experts, along with the CNRS team.

The CNRS addresses special appreciation and acknowledgement to all those who were involved in the STIP preparation process. It is to be noted that the wide participatory approach was made possible only through the dedication and commitment of all contributors who were deeply concerned about its success. Most contributors have worked beyond their nominal remunerations or totally on a voluntary basis.

The following is a list of all contributors and the main responsibilities they undertook during the formulation and towards the finalization of the STIP Plan.

1. CNRS Team

George Tohmé	President of the Board of Administration	
Mouïn Hamzé	Secretary General	Programme Director
Hassan Charif	Scientific Advisor	Programme Coordinator (2004-2005)
Hratch H. Kouyoumjian	Scientific Advisor	(2002-2003)

2. Contributing Experts

Peter Tindemans	UNESCO Consultant	Formulated the collective vision of the plan, followed up on the work of the task forces and prepared the Basic Report.
Gilbert Frade	Expert in Entrepreneurship Professor at the Ecole des Mines, France	Prepared an analysis on the partnerships between the different parties of STIP and the private sector.
Antoine Zahlan	Independent consultant in science and innovation policy formulation	Prepared a study presenting STIP and analyzed the relation between research and the Lebanese economical and social situation.

3. Task Forces

Four task forces consisting of about thirty senior researchers, university professors and experts prepared the specialized reports, which were the bases for the formulation of the Basic Report. Their names and affiliations follow.

3.1. Task Force on Basic Sciences, Technology and Industry (TFI)

Mohammed Ali Kobeissi	Rapporteur	CNRS Board Member
Ahmed Nasri	Co-rapporteur	CNRS Board Member and American University of Beirut

and the membership of:

Fuad Mrad	American University of Beirut
Joseph Bechara, Melhem Chaoul	Lebanese University
Nashat Mansour	Lebanese American University
Pierret Zouein	Université Saint Joseph
Neemat Frem	INDEVCO Group

3.2. Task Force on Environment, Agriculture and Biological Sciences (TFE)

May Jurdi	Rapporteur	CNRS Board Member and American University of Beirut
H.H. Kouyoumjian	Co-rapporteur	CNRS Scientific Advisor

and the membership of:

Mohamad Farran, Mutasem El-Fadel, Nahla Houalla, Rami Zurayk	American University of Beirut
Gaby Khalaf, Bilal Nsouli, Mohamad Khawlie, Khaled Makkouk	CNRS
Wafa Khoury, Henriette Tohmé, Michel Khouzami, Khalil Melki	Independent experts

3.3. Task Force on Medical Sciences and Public Health (TFM)

Ali Bazarbachi	Rapporteur	American University of Beirut
Antoine Hajjar	Co-rapporteur	CNRS Board Member

and the membership of:

Nayef Saadé, Samir Atweh	American University of Beirut
Camille Nassar, Nadim Karam	University of Balamand
Fahd Nasr	Lebanese University
Fouad Hashwa	Lebanese American University

3.4. Task Force on Socio-Economic Analysis (TFSE)

The report on the analysis of the social and economic situation in Lebanon, and the assessed impact of STIP, has been undertaken by experts from the Economic and Social Commission for Western Asia (ESCWA).

Mohamad Mrayati	Rapporteur	Regional Advisor on Science and Technology
Omar Bizri		Technology Team Leader
Mansour Farah		Senior Information Technology Officer

4. Translation

Jean-Eileen Abou-Chacra

Mona Assaf

Amale Habib

5. Research Assistants

Rula Atweh (CNRS)

Elise Noujeim (CNRS)

Sarah Colautti (UNESCO, Paris)

The National Council for Scientific Research (CNRS)

AN OVERVIEW

The National Council for Scientific Research (CNRS) is a national public institution which, since its establishment by law on 14 September 1962, has been entrusted with a double mission: the first advisory, the second executive.

The consultative mission of the CNRS involves the formulation of guidelines for national scientific policies aimed at enhancing the development of the country.

As part of its executive mission, the CNRS secures the promotion, organization and realization of these policies in programmes of action, implemented in its own research centres or in collaboration with other academic, research and development institutions.

Reporting to the Prime Minister, the CNRS is an autonomous office directed by a Board of Directors and managed by a Secretary General.

The Board of Directors consists of fifteen prominent scientific and administrative Lebanese personalities appointed by the Council of Ministers. Since its establishment, the CNRS has had two chairmen: the late Joseph Naggear chaired the Board of Directors from 1962 until 1992. Professor Georges Tohmé has chaired the Board since 1992.

The Secretary General, appointed by the Council of Ministers, is the Head of the General Secretariat, representing the scientific, administrative and technical body of the CNRS. Professor Mouïn Hamzé has been the Secretary General of the CNRS since 1998. Previous to Dr. Hamzé, in chronological order from the establishment of the CNRS, this post was occupied by: the late Nicolas Rizkallah (acting), the late Joseph Naffa'h, Moustapha Soufi (acting) and the late Hafez Koubeissi.

As part of its main mission, the objectives of the CNRS are, firstly, to develop scientific research in Lebanon and to direct that research to respond to the needs

of the country and to the evolution of science and innovation worldwide. It is in this perspective that the programmes and initiatives of the CNRS are formulated.

Though the main programmes are continuous, the initiatives are formulated so as to reinforce scientific research in all its aspects and at all levels: political, strategical, social and institutional. The CNRS considers the creation of its own research centres as a major achievement, namely: the National Centre for Geophysics, the National Centre for Marine Sciences, the Lebanese Atomic Energy Commission and the National Centre for Remote Sensing.

The improvement of researchers' status is another exemplary achievement. The CNRS has enhanced researchers' status through an elaborate system of evaluation and validation of their research work, with concern for quality and performance. However, the number of full-time researchers in the CNRS has been reduced due to the Lebanese government's austerity policy which has frozen all new recruitment to the public sector. Yet CNRS research centres have constituted a way around this difficulty, as focal points attracting a large number of researchers and students in their fields of specialization.

The CNRS has also opted to open up to a wider scope of work. The expansion of its mandate was stipulated in law No.576 of 11 February 2004 to include, beyond the basic and applied sciences defined in the original mandate, human and social sciences. Thus, economics, management, law, linguistics, history of sciences, ethics of science, as well as arts and other disciplines were introduced as new fields of research within the CNRS programmes.

Finally, as part of its mandate as advisor to the Lebanese Government, the CNRS has elaborated a new Science, Technology and Innovation Policy (STIP) with the aim of formulating a five-year programme of action to promote the new orientations in scientific research in Lebanon and to cope with societal needs.

CNRS Programmes

The scientific policy of the CNRS is translated into concrete programmes of action that are placed in line with its objectives to organize, implement, coordinate and activate scientific research in Lebanon. The main programmes representing the nucleus of its activities, and which are executed regularly, are the following:

The Programme to Support Scientific Research

The Programme for the Support of Scientific Research was included in the mandate of the CNRS at the very beginning. It covers projects that are totally or partially financed by the CNRS and which are executed in cooperation with public and private universities and national research institutions, or in the CNRS affiliated research centres.

This Programme has witnessed substantial growth in the past five years, benefiting from a large portion of the CNRS budget. Since 1998, this Programme has supported more than 1,000 projects, with a total budget of six billion Lebanese pounds, covering all research areas within the CNRS mandate.

The Programme to Develop Human Resources

This Programme, launched at the establishment of the CNRS, is managed in parallel with the scientific policy programmes, so as to prepare the potential human resources dedicated to scientific research.

The Programme had a forced interruption during the period of civil strife from 1975-1990. Financing was re-established in 1999, and between 1999 and 2005, a total of 600 scholarships were granted. Recipient researchers, working at the CNRS or in various universities in Lebanon, form the majority of the current scientific community in Lebanon. Some of them occupy high positions in the public and private sectors, which is a sign of the importance of the continuity of this Programme.

Within the main objectives of the CNRS , this Programme is defined according to priorities identified annually by the CNRS in the framework of its scientific policy and development needs in Lebanon. It is based on a rigorous process of selection and strict criteria of competence and distinction. This Programme is announced yearly, offering scholarships for Ph.D. studies at prominent universities in Europe, the United States of America and Canada as well as in Lebanon for doctoral studies co-managed between foreign universities and CNRS affiliated centres. About twenty scholarships are offered annually, selected from an average of 150 applications received by the CNRS.

Still within its objectives to enhance competence and to develop human resources, in 2002 the CNRS launched a new scholarship programme for the first cycle of university studies, for the laureates of the Lebanese Baccalaureate opting for university education in Lebanon. Twelve distinguished students benefit from this programme every year.

CNRS Research Centres

With increasing need for scientific research in special areas, which do not fall within the priorities of other Lebanese institutions, the CNRS established four research centres, namely:

- **The National Centre for Geophysics**

This Centre was established in 1975, when the CNRS regained control of the Ksara Observatory. The Centre is currently interested in research on active seismic fault

lines in Lebanon and in the nearby coastal areas. The Centre's activities also include studies on seismic activities and terrestrial magnetic field measurements, from its observatory in Qsaybeh. It also carries out mapping of sea floor topography and magnetic field distribution.

The Centre is the national reference for seismic activity measurements. It is operated by a small number of experts and researchers in its headquarters in Bhaness and its branch stations in Houka, Fak'ha, Hasbaya and Ansar.

• The National Centre for Marine Sciences

This Centre was established in 1977, to carry out research in marine sciences, particularly sources and factors of coastal pollution, the preservation of sea ecosystems and the protection of biodiversity, as well as to undertake studies on the development of sea resources. The Centre is located in Betroun and has an additional station in Jounieh. It has a limited number of researchers.

• The Lebanese Atomic Energy Commission (CLEA)

The CLEA was established in 1995, through a support grant from the International Atomic Energy Agency. The CLEA's headquarters are located in Beirut, where approximately forty researchers, experts and technicians work.

This is the national agency mandated to establish the radioprotection infrastructure of all radioactivity sources emitting ionizing radiation in Lebanon, and to carry out surveys on possible radioactive pollution. The CLEA cooperates closely with the Ministry of Public Health and the Directorate of the Custom Duties Authority, particularly in controlling the impact of radioactive sources and equipment used as sources of ionizing radiation.

The mandate of the CLEA has been extended to cover the monitoring of the radioactivity of imported and exported commodities and related equipment, and to maintain a national record of all radioactive materials and equipment in Lebanon. Its aim is to protect all personnel working in this field and the general public from radioactive risk and pollution.

It is also mandated to establish a plan for the treatment of all radioactive waste from industries and hospitals. The CLEA is mandated to issue utilization permits to all institutions using ionizing radiation.

The services of the CLEA are a source of income for the CNRS. They also underline the function of the CNRS to provide services to the Lebanese public in various areas (e.g. technical, environmental, public health, natural resources and public safety).

The CLEA has nine research laboratories in the fields of the environment, health and material sciences.

• The National Centre for Remote Sensing

This Centre was established in 1996. Its activities are focused on processing satellite images and data to update Lebanon's geological and natural resources maps and to optimize the exploitation of these resources. The Centre employs a pool of researchers and experts in complementary fields, so as to maximize the benefit from satellite remote sensing technology and from Geographic Information Systems (GIS) in national development programmes.

Institutional Cooperation within Lebanon and Abroad

In all its activities and programmes, the CNRS has developed strong relationships with the major universities in Lebanon, particularly through its programmes to support scientific research and Ph.D. scholarships. Through the latter, the CNRS has also developed relationships with many universities outside Lebanon. These relationships have been extended to cover a wide range of ministries, public institutions, UN agencies and other international and regional institutions operating in Lebanon who are interested in the CNRS and its specialized centres.

Moreover, the CNRS has a wide range of bilateral and multilateral cooperation agreements with French institutions (Programme CEDRE), the European Commission, scientific and academic institutions in Arab Countries (in particular with Syria through the Scientific Libano-Syrian cooperation programmes), and with Europe and the United States of America. These agreements cover many specialized regional and international research institutions.

The CNRS hopes to develop closer relationships with donor agencies and with scientific research networks in the Arab region and in Europe. The CNRS is keen to participate actively in all efforts to benefit from European support mechanisms for research and development in Lebanon.

Scientific Information

Parallel to its programmes and activities to support scientific research, the CNRS has developed policies to disseminate scientific information, providing a national forum for the publication of the results of research in its *Lebanese Scientific Journal*. The CNRS also publishes a quarterly *Newsletter*. In addition, the bi-annual Research Directory, listing all research projects sponsored or supported by the CNRS provides a useful reference tool for researchers, along with the various databases available within the CNRS on these projects.

Constraints

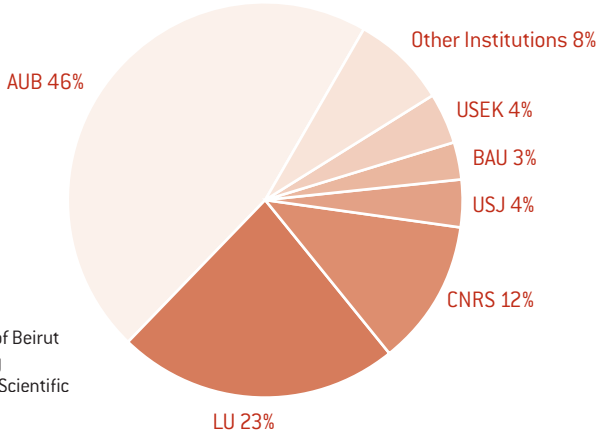
The law that established the CNRS in 1962 stipulated that 1% of the national budget would be allocated to scientific research. However, this part of the law has never been implemented. In 2005 the CNRS budget totaled 9 billion Lebanese pounds (US$6 million), together with €600,000 from various European support programmes (INCO, RTD, SMAP, etc.). Eighty percent of the CNRS budget is allocated to affiliated research centres and to research programmes. The recent economic crisis in Lebanon had severe repercussions on scientific research in Lebanon. For instance, the government policy of freezing all recruitment in public institutions, has limited the potential expansion of the CNRS and its affiliated centres. Nonetheless, the CNRS has managed not to reduce the capacity of these centres for research. However, as a result of this policy, the CNRS has not been able to accommodate recipients of scholarships who are expected to serve in its scientific programmes after completing their Ph.D. studies. They have been obliged to accept part-time teaching posts at certain Lebanese universities or they have chosen to emigrate.

There are other institutional constraints too, facing the development of scientific research in Lebanon. For instance, there is very limited potential to expand specialized research centres. There is also an almost total lack of incentives and encouragement for scientific research from private institutions or from the productive sectors, in addition to the other constraints mentioned in the document.

The STIP stipulates concrete proposed measures to overcome at least some of these constraints.

The CNRS has incorporated the STIP guidelines in its internal policies and operations to reinforce the credibility of its programmes and the effective support it is offering to scientific research in Lebanon.

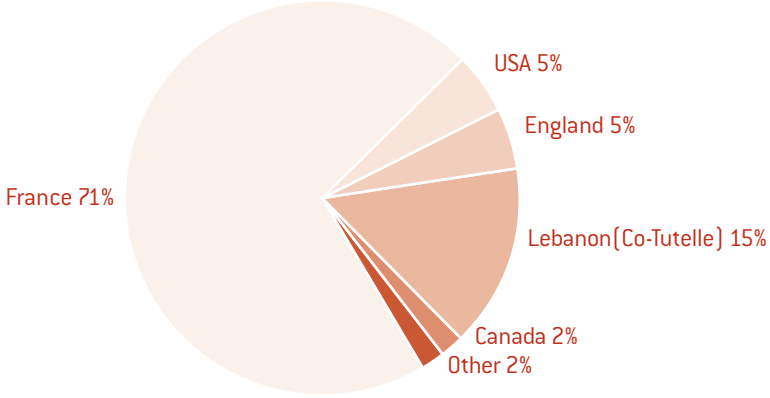
CNRS Research Funds by Institution (2002-2007)



AUB: American University of Beirut
BAU: Beirut Arab University
CNRS: National Council for Scientific Research
LU: Lebanese University
USEK: Université St. Esprit de Kaslik
USJ: Université St. Joseph

Source: CNRS Research, updated October 2008.

Distribution of Scolarships by Country (1999-2007)



Source: CNRS, updated October 2008.

List of Acronyms and Abbreviations

AFTA	Arab Free-Trade Agreement
ALECSO	Arab League Educational, Cultural and Scientific Organization
ALI	Association of Lebanese Industrialists
ALMEE	Association Libanaise pour la Maîtrise de l'Énergie et de l'Environnement
AUB	American University of Beirut
AWCR	Arab World Competitiveness Report
BERYTECH	Beirut Technology Pole (Pôle Technologique de Beyrouth)
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAS	Central Administration for Statistics (Lebanon)
CEDO	Consulting, Engineering, Design and Contracting Organizations
CDR	Council for Development and Reconstruction
CLEA	The Lebanese Atomic Energy Commission
CNRS	Lebanese National Council for Scientific Research
CoE	Centre of Excellence
CUS	Country Unit Staff
DNS	Domain Name Server
EIA	Environmental Investigation Agency
EIU	Economist Intelligence Unit
ESCWA	UN Economic and Social Commission for Western Asia
EU	European Union
EUMEDIS	Europe-Mediterranean Information Society
FDI	Foreign Direct Investment
GCC	Golf Cooperation Council
GDP	Gross Domestic Product
GEANT	Gigabit European Academic Network
GIS	Geographic Information System
GNP	Gross National Product
GPRS	General Packet Radio Service
HACCP	Hazard Analysis Critical Control Points
HE	Higher Education
HRD	Human Resource Development
IA	Implementing Agents

ICSU	International Council for Science
ICT	Information and Communication Technology
IDAL	Investment Development Authority of Lebanon
INCO	Specific International Scientific Cooperation Activities
INSERM	Institut National de la Santé et de la Recherche Médicale
IRI	Industrial Research Institute (Lebanon)
IS	Industrial Sector
ISO	International Organization for Standardization
IUBS	International Union of Biological Sciences
KBE	Knowledge-Based Economy
L.S.O.E.R.	Lebanese State of the Environment Report
LAN	Local Area Network
LARI	Lebanese Agricultural Research Institute/L'Institut de Recherches Agronomique
LAU	Lebanese American University
LEDO	Lebanese Environment and Development Observatory
LIBNOR	Lebanese Standards Institution
LU (UL)	Lebanese University (Université Libanaise)
MAP	Mediterranean Action Plan
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEd	Ministry of Education
MoEW	Ministry of Energy and Water Resources
MoF	Ministry of Finance
MoH	Ministry of Health
MoI	Ministry of Industry
MoU	Memorandum of Understanding
NGO	Non-governmental Organization
NIH	National Institutes of Health
NIS	National Innovation System
NSF	National Science Foundation
OECD	Organization for Economic Cooperation and Development
OMSAR	Office of Minister of State for Administrative Reform
PA	Primary Actor
PMU	Programme Management Unit
CEDRE Programme	Coopération pour l'Évaluation et le Développement de la Recherche
QA	Quality Assurance
QFD	Quality Function Deployment
R&D	Research and Development
RD&I	Research, Development and Innovation
RP	Regular Programme

S&T	Science and Technology
SG	Secretary General
SMAP	The Short and Medium-term Priority Environmental Action Programme
SME	Small and Medium Sized Enterprises
STI	Science, Technology and Innovation
STIP	Science, Technology and Innovation Policy
SWOT	Strengths, Weaknesses, Opportunities, Threats
TERENA	Trans-European Research and Education Networking Association
TOR	Terms of Reference
TPU	Technology Promotion Unit
TT	Technology Transfer
UN	United Nations
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organizations
UNDP	United Nations Development Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UOB	University of Balamand
USEK	Université St. Esprit de Kaslik
USJ	Université Saint-Joseph
WAN	Wide Area Network
WB	World Bank
WHO	World Health Organization
WTO	World Trade Organization

1. Science, Technology and Innovation Policy (STIP):
A Presentation for the General Public

CONTENTS

INTRODUCTION

The evolution of nations is driven by advances in science, technology and innovation. Those countries that have benefited from such advances have secured high rates of economic growth and a high per capita income in the range of US$ 40,000 to $50,000. They have been able to dematerialize and construct a knowledge-based economy. Countries that do not harness the power of science fall behind; those that do, benefit.

Scientific institutions are responsible for advising their governments and societies on the implications of advances in science. The Lebanese National Council for the Scientific Research (CNRS) has been entrusted with this responsibility. This chapter was prepared by Dr. Antoine Zahlan on behalf of the CNRS, to address the wider public in Lebanon. It is a synthesis of reports prepared by task forces – of about thirty Lebanese experts – organized by the CNRS, in consultation with a large number of stakeholders, coordinated by a UNESCO sponsored international expert. The task forces reports and the resulting Basic Report, prepared by the UNESCO expert, discuss issues and objectives recommending science, technology and innovation policies. They provide a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis surrounding each issue. These reports are presented in the following Chapters 2-6 of this document.

The Lebanese Government has made some effort in recent years to support the private sector to pursue available opportunities. But the benefits resulting from such efforts have not been commensurate with expectations. Lebanon has yet to benefit from available expertise. As a result, it has suffered from a massive brain drain and an under-performing economy.

In preparing the new Science, Technology and Innovation Policy (STIP) and its Plan of Action, the CNRS adopted an integrative and incremental approach. Lebanon's entrepreneurial traditions and fluid environment call for flexible national policies that support a wide range of possibilities. The STIP proposed Plan of Action recommends specific Science, Technology and Innovation (STI) policies that would enable Lebanon to lay the foundation for more purposive and vigorous programmes and to increase the rate of expenditure on STI; including a substantial increase in human resources and infrastructure, leading hopefully to a tangible impact on the country's economic growth. The proposed policies seek to achieve their objectives through integrating available resources, building on existing capabilities, benefiting from available knowledge and seeking a tangible expansion of all these factors.

This chapter is organized in three sections:

Section 1: presents a summary of the structure and priorities of the Lebanese economy and its STIP requirements.

Section 2: presents an outline of the required STIP instruments as detailed in the chapters that follow.

Section 3: presents a summary of the recommendations and the Plan of Action concerning implementation and funding of the STIP.

1. STIP and the Priorities of the Lebanese Economy[1]

STI Policies aim to enhance and diversify STI input in economic activities. It is thus important to note that STIP was designed in the light of the structure and priorities of the national economy, as it was assessed by the specialized task forces. Although detailed and accurate statistics on the Lebanese economy are not available, it is possible to highlight some of its major features.

More than 50% of the Lebanese economy is accounted for by services in trade, finance and tourism. Agriculture and manufacturing/industry account for some 20% (**Table 1**). The balance appears to be contributed by electric power generation, construction industry (both at home and exported consulting and contracting services) and transport services. **Table 2** (page 34) presents estimates of Lebanon's GDP.

The positive and negative aspects of the Lebanese economy have been known for a considerable time.

On the positive side, Lebanon enjoys a high level of educational attainments. Some 38% (or more) of the age group 18-24 is enrolled in tertiary education.[2] The country has had access to higher education facilities for more than one century.

On the negative side, Lebanon suffers from low levels of productivity, innovation, competitiveness and a very low level of networking and connectivity between its economic, educational and professional organizations.[3] There are no statistics on productivity especially concerning labour, land, equipment and capital. Estimates of these are generally low: barely 10% of the levels attained in industrial countries.[4]

Table 1: GDP by Economic Activity (%), 2004

SECTOR	1997	1999	2002	2003
Agriculture, hunting & fishing	6.3	10.4	6.3	6.3
Manufacturing	13.5	10.3	13.5	13.5
Electricity, gas & water	1.5	6.6	1.5	1.5
Construction	9.4			
Transport & communication	5.3			
Housing	8.5			
Other market services	22.6			
Trade	21.3			
Non-market services	11.6			
Wholesale & retail trade, restaurants & hotels		32.2	21.3	21.3
Financial institutions, real estate & business services		17.3	31.1	31.3
Government services		7.7	11.6	11.6
Community social & personal services		9.3	Nd	Nd
Others		6.2	14.7	14.7
Total	**100**	**100**	**100**	**100.2**

Source: ESCWA, National Accounts Studies of the ESCWA Region, Various issues, UN, New York. The data for 1997 is from Mouïn Hamzé & Abir Abul Khoudoud, ***Annual Report on Lebanese Agriculture, 2004,*** *Beirut, 2005*

The critical importance of productivity to economic growth was not given due attention in Lebanon. This is surprising in view of the great importance accorded to it in industrial countries, for example, 50% of US economic growth comes from advances in productivity.[5]

Although financial services for trade and real estate are available, entrepreneurs in agriculture, industry, Small and Medium Enterprises (SME) and Consulting, Engineering Design and Contracting Organizations (CEDOs) suffer from a shortage of financial facilities. Furthermore, the fragmentation of land ownership and the high proportion of small industrial enterprises constrain economic growth and

productivity. Although these problems are surmountable, the lack of adequate research on these issues has kept the economy in a static state. Many industrial and developing countries have faced similar problems but have created instruments to overcome them.[6]

Table 2: GDP Estimates from 2001-2003

GDP (US$ billions) At market prices	2001	2002	2003
	16.7	17.3	19.0

Source: Mouïn Hamzé & Abir Abul Khoudoud, ***Annual Report on Lebanese Agriculture, 2004****, Beirut, 2005.*

The following chapters of this document, and cited references, provide convincing and extensive discussions and descriptions of the benefits of STI Policies to all sectors of the economy. The STIP Plan of Action proposes to overcome the present stalemate by adopting the tools of science. In the following sections, brief observations are presented on selected sectors of the economy and STIP solutions are highlighted.

1.1. The Services and Industrial Sectors

1.1.1. The Services Sector

The high share of the services sector (50%) of the GDP means that feasible improvements in productivity would have a massive impact on the entire economy. Information and Communication Technology (ICT), combined with sound management, life-long training and an efficient legal system (particularly the business related legal system) should raise dramatically the productivity of labour and capital employed in the services sector. For example, ICT improves logistics; and efficient inventory management improves the rate of return on capital.

International experience has shown that governments can promote the use of ICT by adopting incentives aiming to reduce obstacles in accessing needed skills and equipment. Such improvements should provide Lebanese consulting firms with exportable services that are much needed throughout the Arab world and the wider developing nations. The export of these services would generate considerable employment for expert human resources.

The STIP Plan of Action identified the deployment of ICT for development as a high priority and stipulates research programmes for the development of ICT in the enterprise sector, as well as in public services. It also stipulates research programmes in the Arabization of software and web technologies.

1.1.2. The Industrial Sector (IS)[7]

The Lebanese government has sought to develop the IS. A detailed report submitted in 2000 by the United Nations Industrial Development Organization (UNIDO), along with many reports prepared by the Association of Lebanese Industrialists (ALI), provide substantial information and recommendations.[8] These reports, prepared in cooperation with the Lebanese government, discuss the full range of problems facing Lebanese industry. Most of the proposed policies involve science, technology and innovation.

From the surveys supervised by the Ministry of Industry during 1994 and 1995, and during 1998 and 1999, the following picture of the Lebanese IS can be put together:

The IS consists of some 22,000 or more industrial establishments; excluding those that fall under power, water and construction sectors. In 1998, the 22,000 firms employed 114,000 employees (including owners) plus some 40,000 seasonal workers. The average number of employees per establishment was between five and six workers (including owners). Ninety-five percent of the firms employed less than ten workers, including owners. Only 1% of the industrial firms in Lebanon had more than 100 workers. There is no information on the qualifications of employees. There is no data on productivity of labour, equipment or capital.

According to the 1998 survey, 88.6% of the industrial establishments fell into eight branches. The largest was that of food and beverages (20.3% of total), the rest in metal products (16.1%), non-metallic products (11.5%), furniture and assimilated products (10.7%), clothing and fur (10.3%), wood products excluding furniture (10.2%), leather and tanning (5.9%) and textiles (3.7%).

A large number of industries exist in Lebanon however there is limited information concerning employment, turnover, profits, competitiveness and markets. Amongst these, one finds fashion, media, jewellery, printing and publishing, translation, ICT, consulting and contracting industries and most likely many others. These industries may already be making significant contributions to the Lebanese economy. Strengthening these activities could be of considerable long-term importance since all of these are knowledge-based, where Lebanon already has a comparative advantage.

Industrial output was US$3.95 billion, of which input expenditure accounted for $2.25 billion: 80% for raw materials, 8% for fuel, oil and electric power, 5% for packaging. Value added totalled $1.7 billion. Average value added per worker was $14,958. Investment per worker increased from $1,382 in 1994 to $3,272 in 1998.

It is clear from all these reports that the Lebanese industry suffers from low technology, its small scale and the low level of productivity reflected in the low value added per worker equivalent to, roughly, 10% of prevailing levels in industrial countries at the low technology end, and some 5% of value added at the high technology end.

These reports and the related STIP Task Force Report on Basic Science, Industry and Engineering also emphasize the lack of adequate test facilities and quality controls on the output of Lebanese industries, especially in the food and drink sectors. They discuss how these shortcomings bear negatively on exports.

The surveys discussed in these reports also found that of the ten major difficulties cited by industrialists, four were related to financial services (level of interest rates, access to long-term loans, access to short-term loans, issues of collateral guarantees); three were related to public policy (cost of electricity, high level of social contributions, high level of customs duties); two were related to regional and international competition; and one was related to lack of access to leasing of equipment.

Some of these difficulties arise from the small size and low productivity of firms. Yet, Lebanese firms have not sought to overcome these difficulties by merging with other firms. Elsewhere, mergers and acquisitions are promoted by financial organizations. A number of measures can be adopted by small firms to improve their performance. They can cooperate to reduce the cost of raw materials through bulk purchases, improve their marketing capabilities through cooperative arrangements and establish joint facilities to lease equipment.

The Task Force Report on Basic Sciences, Technology and Industry (TFI)[9] stressed the need for STIP to:

- Improve the management of energy, water and other natural resources
- Reduce the cost of industrial operations
- Promote the use of ICT
- Strengthen the inputs of Research, Development and Innovation (RD&I) for development

1.2. Environment, Agriculture and Biological Sciences

The Task Force on Environment, Agriculture and Biological Sciences (TFE) was established to examine issues concerning the environment and agriculture.[10] It identified four major challenges the Government of Lebanon needs to address. All four challenges have immediate and long-term socio-economic implications.

These challenges are to:

(1) Stabilize coastal deterioration through sustainable management

(2) Adopt the integrated water management approach for an effective supply demand balance

(3) Grasp new agricultural economic opportunities

(4) Improve nutritional food quality

The issues underpinning these challenges concern the economic, environmental and health needs of the entire population. They also concern the tourist industry and employment, seeing as 40% of the labour force is employed in these activities.

Addressing these issues provides new opportunities for innovation along the following lines:

- Impact on cultural heritage
- The creative expansion of tourism, including health care tourism
- The modernization of Lebanese agriculture
- The empowerment of local communities

1.2.1. Environment: Stabilizing Coastal Deterioration through Sustainable Management

The coastal zone has undergone considerable deterioration. Addressing this challenge is of considerable importance for the following reasons: 70% of the population lives in the coastal zone, the coastal zone contributes significantly to the biodiversity within Lebanon, and it is of prime importance to the tourism industry. It is thus of the utmost urgency to introduce appropriate management technologies to arrest its deterioration and sustain its recovery.

The TFE noted that the coastal zone has received some attention over the past decade and that a number of projects are currently underway. Yet these efforts are still too limited in scale. Greater effort is required to safeguard this national asset.

Lebanon suffers from chronic water shortages caused by supply and management problems. Surprisingly, surface water is underutilized. The government is supporting an ambitious and expensive programme of reservoir construction for the storage of several hundred million cubic meters of water to be implemented over the coming ten years. Little attention has been focused on alternative small-scale water projects, which would be less costly and less likely to cause socio-economic and environmental disruptions.

Lebanon's irrigation infrastructure is obsolete and was damaged during the civil war; it requires extensive rehabilitation to restore agricultural activity and to extend irrigation into new areas. Almost 80,000 to 90,000 hectares are irrigated out of a potential 180,000. Irrigation water is still conveyed in open canals. The most common method of irrigation is by flooding the fields. Irrigation efficiency is no more than 30 to 40 %. Significant losses are due to cracks in the canals and to evaporation.

A set of research areas has been identified by the TFE. These are:

- Sustaining water sources
- Watershed management
- Assessment of ground water aquifers (local and shared)
- Reduction of seawater intrusion and salinization of soils and aquifers
- Optimizing water use (quantity and quality) in agriculture and forests

1.2.2. Agriculture

Mouïn Hamzé and Abir Abul Khoudoud noted that on the basis of the 1999 census conducted by the Ministry of Agriculture (MoA) and the UN Food and Agriculture Organization (FAO): "248,000 hectares (ha) of lands were cultivated (24% of the Lebanese territory), of which 42% were irrigated and only 2% were under greenhouse production. An additional 53,137 ha were fallow lands which had been abandoned for more than five years." [11]

Agricultural activity is underdeveloped, poorly managed, utilizes inefficient technologies, and its output is of questionable quality.[12]

"More than half of the farms are small in size and less than 2% exceed 10 ha. Almost 75% of farmers cultivate an area less than 1 ha each and account for 20% of total cultivated land. The average farm size in Lebanon is 1.27 ha: it ranges from 0.6 ha in Mount Lebanon to 2.9 ha in the Bekaa." [13]

"The agricultural sector employs about 195,000 holders, up from 143, 000 in 1961 (MoA/FAO, 2000)... Fruit trees constitute around 53.7% of the total cultivated area. Cereals, vegetables, legumes and industrial crops cover 21%, 15.7%, 3.7% and 3.9% of the total cultivated area, respectively. Crop production represented 73% of the total value and animal production was 27% of the share." [14]

Agro-food industries constitute some 25% of Lebanese industry and include: arack, wine, confectionery, canned fruits and vegetables, bakery products, olive oil and many others.

In order to improve agricultural activity, Hamzé and Khoudoud suggest that Lebanon needs:

- Financial services to upgrade the low technologies in use
- A reduction in the high taxes imposed on imported raw materials (80% of materials used by industry are imported)
- High quality standards to benefit from various international trade agreements[15]

The STIP Plan of Action stipulates that the agricultural sector would benefit from scientific inputs to increase land and labour productivity, the adoption of business models to reduce the constraint of land fragmentation and an increase in the use of sophisticated green houses.

There are no estimates of the economic returns on various types of improvements; doubtless these could be very significant and would certainly improve the type of jobs available in the agricultural and agro-industrial sectors.

Agro-food exports from Lebanon have been on the increase. Lebanon has yet to exploit to a significant degree the international market for Lebanese food products created by the international diffusion of Lebanese restaurants and groceries – based on the healthy Lebanese diet – in Western countries.

Currently, the bulk (71%)[16] of its agro-food exports goes to the Golf Cooperation Council (GCC)[17] countries. There are no current estimates of the potential value of the international market. But doubtless it is substantial, especially the high quality products which reflect the full range of Lebanese cuisine and healthy diet, based mostly on vegetables, fruits, olive oil and minimum amounts of meat.

The Lebanese Government subsidizes the production of wheat and tobacco.[18] Research, Development and Innovation (RD&I) could contribute significantly to improving the use of these financial resources.

The TFE recommendations focus on:

- Eliminating obstacles preventing the optimization of the use of existing resources
- Strengthening the scientific base to promote increases in productivity and quality of agricultural output
- Shifting agricultural activities to meet the demand of the high value added end of the tourist industry

- Expanding the development of a seed industry to serve the national and regional markets
- Servicing the regional chicken farming industry with vaccines and chicken feed
- Expanding and diversifying marine and fish farming (pisiculture)[19]
- Expanding the food industry in the areas of canning and frozen food
- Organic production of plants and animal food products
- Medicinal, agricultural and industrial use of local biodiversity
- Improving nutritional food quality

1.3. Medical Sciences and Public Health[20]

The TFE Report found that the limited research in the medical sciences in Lebanon has affected the quality of medical education, as well as the quality of continuing medical education. The quality of educational activities depends on quality research programmes. Research capabilities are also essential to the design of medical and health policies and services, as well as to the regional and international status of Lebanon as a centre of high quality medical services.

The Report noted that it is premature to specify research objectives. It recommended the establishment of multi-disciplinary research centres in molecular and cellular biology – to the benefit of medical and other relevant areas – to enable Lebanon to position itself to attract research contracts and to participate in cooperative regional and international research programmes.

The Report recommended the development of Ph.D. programmes to enable Lebanon to sustain high quality medical education and medical services.

The importance of advances in medical and pharmacological sciences in developing countries has been shown to be critical in the treatment of costly diseases like HIV. India and Brazil, for example, have been able to secure concessions from the World Trade Organization (WTO) to develop their national pharmaceutical industries to respond to a national emergency.

Roughly 40% of Research and Development (R&D) in developing countries is in medical sciences. It should be possible to develop cooperative research programmes in selected areas which would benefit from these research capabilities. It is well known that international pharmaceutical firms do not devote much attention to the drug requirements within developing countries (which cannot afford to pay high prices for their drugs). Lebanon could develop

a strong national base in medical research and extend this base by cooperating with other developing countries.

The TFE Report also recommends pursuing subcontracting medical research projects from international firms. Subcontracting in the medical and pharmaceutical fields is currently standard practice in a number of developing countries. Obviously, improving medical research in Lebanon enhances its competitiveness in securing such research subcontracts.

1.4. Research in Other Applied and Basic Sciences

The basic objective of the STIP Plan of Action is to enhance science and technology inputs to promote the socio-economic development of Lebanon. An integral part of this responsibility is to contribute to the sustenance of a modern educational system in addition to promoting innovation in applied fields.

Lebanon is in need of RD&I activity in the hard sciences and in technology, as well as in management, business and social fields. A better understanding of the obstacles and challenges that businesses face is of paramount importance.[21] For example, providing better financial services to the industrial and agricultural communities is contingent on understanding the commercial and risk environments surrounding such services as well as inventing/adopting appropriate risk management methods. This subject needs to be researched and solutions found; otherwise no amount of RD&I will overcome present obstacles.

The rate of the obsolescence of technology is relatively high; it is estimated that half of science and technology knowledge acquired by a university graduate becomes obsolete within five years of graduation. This means that university courses and curricula – particularly in basic sciences and engineering – must be updated constantly. A university professor in any field of science or engineering will be unable to provide quality teaching without undertaking research.

The large number of university students in Lebanon call for a highly diversified academic expertise that can be maintained only through research.

It is impossible to predict the practical and economic importance of scientific research. Neither Einstein's theory of relativity nor Alan Turing's research on computable numbers was of practical usefulness at the time. Yet in a short time, these advances had great practical importance.

Some areas of research, such as nanotechnology and molecular biology, promise to be of considerable economic importance in the immediate future. It is thus reasonable to expect that funding would be provided to support serious activities

in these fields. Such RD&I support would enable researchers and technologists to be aware of international activities and thus to be able to contribute to the applications of these advances through Lebanese industry.

High quality scientific research enables national scientific communities to establish links with international science. An eminent scientist would be able to assist younger scientists and colleagues to have access to international science. The STIP Plan of Action stipulates many activities to this effect.

1.4.1. Financial Sector

The successful impact of a national STIP on the national economy depends on the existence of a strong financial sector. Numerous studies (cited above) have identified the limited availability of commercial financial services; these constrain the economic performance of the Lebanese agricultural and industrial sectors. Furthermore, the absence of appropriate financial services for consulting and contracting firms has restricted their activities both in the Lebanese and the international markets. Lebanese banks would also derive substantial profits generated by such services.

Financial capital is not lacking in Lebanon; what is lacking is the ability to undertake risk assessment which is essential for capital to be used fruitfully. The provision of financial services involves strong capabilities in risk assessment and management without which capital is only of limited utility. Risk assessment and management capabilities are well known and can be readily secured. The STIP Plan of Action stipulates active research programmes in mathematical modelling, including financial and economic applications.

In industrialized countries, the banking sector intermediates between economic organizations. It provides independent information services that enable firms to operate in a fast changing world. For example, financial institutions play a major role in mergers and acquisitions, and through this function, assist the formation of competitive firms by merging smaller firms. These services are an important source of bank revenue.

1.4.2. Improving the Legal System

A modern legal system and independent regulatory services are essential to a modern economy. Mr. Hamzé and Mr. Khoudoud noted that the Lebanese Government is seeking to modernize the legal system.[22] The STIP Plan of Action stipulates many activities to streamline procedures and administrative practices, including the reform and modernization of the legal business environment.

The efficiency and effectiveness of the legal system – particularly the business related aspects – are of considerable importance to successful economic activity. However this falls outside the scope of STIP.

1.4.3. Consulting, Engineering, Design and Contracting (CEDO)[23]

CEDOs are orphan activities in many developing countries. In Lebanon, a number of CEDOs have achieved international status and account for the employment of a substantial number of professionals. The export of CEDO services is not noted in Lebanese statistics. Yet, they may account for an important share of invisible Lebanese exports.

CEDOs provide important employment opportunities for engineers and numerous other professionals, particularly in countries with a limited industrial base. CEDOs provide a critical nexus of relationships between the financial and industrial sectors. The financial sector could benefit substantially from extending financial services to consulting and contracting firms to enable them to assume the role of prime contractors. A well developed STIP could establish a large industrial base supported by the export of CEDO services.

CEDOs also provide an important source of RD&I contracts to specialized organizations and university professors. Currently, Lebanon-based CEDOs subcontract their RD&I requirements abroad. The STIP Plan of Action stipulates many activities to improve the relationships between CEDOs and RD&I organizations in Lebanon.

Although consulting and contracting firms have been operating in Lebanon for more than forty years, they have not been totally integrated into the national economy. Integrating the operations of these firms into the industrial and service sectors and the improvement of industrial information technical consulting services, could make significant economic and employment contributions.

2. Instruments for a National STI Policy

Lebanon possesses many of the essential organizations needed to implement an effective STIP. What is presently required is to develop, deepen and connect these constituents sufficiently to empower the national science and technology system.

The total process of STIP, including its Plan of Action, is concerned with only one part of this science and technology system: the RD&I component. However, unless the other constituents are addressed, increasing RD&I activity may not lead to the desired socio-economic outcomes, as is stated in the Basic Report, in Chapter 2 that follows.

It is clear from the studies undertaken by the STIP teams of experts that several measures are needed to promote and benefit from RD&I. The measures proposed to this effect aim to strengthen the enabling environment through:

- The transformation of the learning environment and the corporate culture
- The establishment of effective connectivity between the components of the national science and technology system

The proposed measures fall in two broad categories:

(1) Measures that enhance relationships between organizations of importance to the performance of STIP.

(2) Measures that strengthen the organizations needed to implement STIP.

It is impossible to plan, manage and coordinate centrally a large number of entrepreneurial activities. It is recommended by the STIP teams of experts that a National Steering Committee be formed deriving from the parties involved in the implementation of the proposed STIP (including the CNRS). This Steering Committee is to supervise the planning, coordination and management of the programme to be undertaken by a Programme Management Unit (PMU).

2.1. Establishing Effective Relations

The establishment of effective technical and economic relations between the many partners involved in economic and industrial development is low in cost and contributes to the translation of scientific know-how into socially and economically useful products.

The absorptive capacity of large and small organizations for new technologies has been found to be dependent on the prevailing learning culture as well as on corporate culture. A variety of instruments have been found to strengthen the learning environment.[24]

The measures proposed below seek to integrate existing organizations and activities and to increase their ability to benefit from available know-how. Improving connectivities, clustering and networking of industries at the national, regional, diasporic and international levels is known to accelerate the rate of economic growth. All the measures recommended below are consistent with these notions.

2.1.1. Professional and Scientific Societies

Scientific associations facilitate communications between professionals, resulting in the transfer of knowledge between professionals engaged in RD&I, in

applications and in education. These associations also serve to inform society on advances in science as well as to maintain channels of communication with the international scientific community.

Scientific societies promote and facilitate formal and informal meetings between professionals. They also promote innovation through public debates and lectures and the publishing of annual national surveys on specific areas of science and/or technology.

In some specialized fields of S&T, the numbers of specialists within Lebanon may be too small to support a vigorous organization. In such cases, it is in the national interest to support organizations - within the STIP implementation mechanisms – with a regional and/or international membership. Alternatively, the CNRS could support scientific workers based in Lebanon to participate in the activities of regional and leading international organizations.

2.1.2. Brokers and Entrepreneurs

In industrialized countries, brokers and entrepreneurs initiate innovative, bilateral and multilateral relationships between firms (national and international). They play an important role in developing public support for their ideas and contribute to raising capital to finance investments. In Lebanon, the number of such individuals is substantial in the commercial field but is very small in the industrial field. The STIP Plan of Action examines ways and means through which it could encourage the growth of brokers and entrepreneurs in the industrial field.

2.2. Improving Critical Organizations

Lebanon already possesses several critical institutions, but they need further improvement and development to enable them to support the effective use of RD&I and to contribute to the modernization of the economy. Four such institutions are of critical importance at the present stage. These are institutions that provide: information services, standards and testing services, high quality vocational and technical schools and statistical services. Others will be needed at later stages.

2.2.1. Information Services

Participants in the application of new technologies need access to considerable sources of information on local firms, on local and regional economies and on international expertise and know-how. Such sources of information are not readily available in Lebanon. Overcoming this shortage is of considerable importance to any sound programme.

The STIP programme stipulates two mechanisms for dissemination of information relating to STI in Lebanon, namely:

(1) The establishment of a Lebanese STI Observatory: a small team is to be established at CNRS that would develop into a Lebanese National STI Observatory.

(2) The establishment of public and professional information units for selected areas. Their tasks world be to provide all stakeholders in the Lebanese society with the highly relevant information that will be accumulated through the STIP Programme.

2.2.2. Standards and Testing Services

The establishment of an effective and high quality standards bureau and the government machinery to implement standards is of vital importance to the Ministries of Economy and Trade, Agriculture and Health, as well as to the municipal authorities. Lebanon has only limited testing, standards and implementation facilities. The STIP Plan of Action stipulates several activities to improve the existing situation in this area.

2.2.3. Innovation in Vocational and Technical Schools

High quality technical and vocational schools contribute to the innovation needed by Small and Medium Sized Enterprises(SME). To date, these organizations have not been encouraged to become a source of innovation. Incorporating innovation into their programmes should enable them to integrate more efficiently with Lebanese SMEs; they should also prepare their graduates for pioneering and innovative carriers. Furthermore vocational and technical schools could provide critical linkages between local industry and RD&I centres.

The Repair and Maintenance (R&M) of sophisticated electronic equipment in Lebanon – and throughout the region – is a multi-billion dollar business. Lebanon is well situated to organize, manage, staff and support such services. R&M involves a considerable amount of spare parts which could provide opportunities for local manufacturing, particularity to accommodate the lack of original spare parts in the local markets, or their very expensive cost. The management of vocational and technical schools jointly with the CNRS (within the STIP implementation mechanism) could sponsor studies of specific R&M markets in the region aiming to encourage local entrepreneurship in the business of R&M. The CNRS could also provide technical and vocational schools incentives to promote the formation of R&M firms by members of their staff and graduates.

2.2.4. Statistical Services[25]

Accurate and up-to-date statistics are scarce in Lebanon. An effort to bridge this gap in knowledge depends on a better appreciation of the importance

of comprehensive, accurate and timely statistics. Effective economic and STI plans require empirical and up-to-date data on: labour, equipment and capital productivities, labour turnover, qualifications and skills, industrial statistics, inventories, royalties payments, expenditure on R&M and training of workers.

To this effect, the CNRS considers the Central Administration for Statistics (CAS) in Lebanon, as an important partner in the implementation of STIP. Joint efforts would be undertaken with the CAS to provide all partners in the STIP (particularly the proposed Lebanese STI Observatory and the specialized information units) with relevant, timely and accurate statistics. Each Primary Actor (PA) of activities is expected to supply the CAS with a list of items where vital statistics are required, along with a list of sources where these data can be collected. The CAS is expected to take necessary action to collect data, process it and provide easy access to all concerned.

3. Implementation and Funding of STIP

A detailed STIP Programme was proposed by the task forces.[26] A Plan of Action is recommended; it incorporates project planning and the establishment of procedures. The task forces recommended a range of activities. Some of the proposed activities require further planning.

Expected Outcomes, Monitoring and Evaluation

In order to chart the performance of the STIP Plan in creating tangible results, a quantifiable metric is preferably needed. One, however, must be realistic in this respect. Proper overall economic and social stimuli and conditions, which are not the subject of the STIP Plan, need to be in place. Moreover, a single five-year STIP Plan must evolve into a continuous effort to lead to sustainable improvements.

Two aspects of the proposed STIP recommendations are considered here: (i) project management of the implementation of STIP and (ii) funding.

3.1. Project Organization, Responsibilities and Management of the Implementation of STIP

In view of the vital importance of networking and peer-based management to the success of the proposed STIP, it is recommended to establish a National Steering Committee, as stated above. This high level Steering Committee – which would include expatriate Lebanese scientists and industrialists – is to supervise, facilitate and assist in the organization and management of the proposed programme. The CNRS is to assume a management and leadership role within the National Steering

Committee through the establishment of an implementation mechanism, or a PMU.

The PMU will have the overall responsibility to initiate activities, approve plans, allocate money, and establish a reporting, auditing and evaluation mechanism of the STIP Plan.

The CNRS should also establish financial, administrative and other guidelines for the PMU, in consultation with the Steering Committee.

For each activity or group of activities, an organization (which may also be a consortium of organizations) will be identified as a PA, to formulate a detailed implementation plan and to set up the actual implementation agents. PAs report to and are financed by the PMU. A University Consortium comprising – the main universities should be set up for some of the measures, implicating joint responsibilities.

The National Steering Committee would consider three different and inter-related issues:

(1) Increased funding of RD&I through STIP Plan of Action.

(2) Networking of the economy with RD&I activities.

(3) Networking of researchers nationally, regionally and internationally.

There already exists a substantial RD&I infrastructure in Lebanon. Research centres vary in size, relevance and competence. RD&I falls into two broad categories: basic research and applied research. The difference between the two is a matter of time scale. Applied research aims to solve immediate technical problems, while basic research aims to address more fundamental questions.

Currently, the RD&I needs of Lebanese and regional firms are supplied by international firms. Needless to say, there is a regional and international market for RD&I services. Multinational companies have already established substantial RD&I centres throughout the developing world, and would be inclined to subcontract RD&I work arising in the region locally. Such development could be lucrative; it could attract thousands of Lebanese scientists who are currently abroad, with all the obvious accompanying economic benefits to the country.

One objective of the STIP is to create conditions that would attract international firms to locate RD&I centres in Lebanon.

Opportunities in RD&I arise in the fields of agriculture, medical and pharmaceutical sciences, civil engineering, chemical sciences and in many others areas of technology. Since research activity in Lebanese universities is limited, it would be important to encourage the formation of teams of researchers based on several campuses. The effective articulation between RD&I centres and businesses could lead to mutually beneficial relationships. The STIP Plan of Action stipulates the formation of many types of R&D teams, including joint participatory units and joint implementation task forces to share in the implementation of the Plan.

3.2. Increased Funding for Research, Development and Innovation (RD&I)

Statistical data on RD&I expenditure in Lebanon are very incomplete. RD&I funding was a mere US$7.45 million in 1996; this was seemingly the latest figure available in 2003.[27] Lebanon's GDP in 2001 was $16.7 billion; this means 0.05% of GDP was devoted to R&D, a very low figure indeed, amongst the lowest in the world. The recommended value for developing countries is 1% of GDP; India and China are seeking to exceed this value. At the 1% level, Lebanon's appropriations towards RD&I would be about $200 million annually.

The recommendations – for STIP six-year period on the subject of RD&I – proposed by the task forces concerning funding were very modest. They proposed that a six-year programme be adopted, to be followed later by similar planning and programmes. The Preparatory Year (Y0) is to be devoted to planning the projects in detail and to establish the teams and management committees. If the various supporting measures mentioned earlier are adopted simultaneously, these investments should be able to contribute significantly to the economy.[28] The total budget estimated for this first phase, over the six-year period, is 50 billion Lebanese Lira (LL).

Plan of Action

A Plan of Action has been drawn up that describes in great detail what needs to be done before and during the first year of the STIP Plan of Action. It proposes suggestions on actions needed to start carrying out the highest priority activities, which need to be agreed upon during national seminars of stakeholders. On that basis, formal approval by the government has to be obtained for the STIP Plan, its budget, the mandates and the coordination structures at the government level.

This Plan of Action describes all the steps that need to be set successively or in parallel to implement the STIP Plan. This Plan is reported in all its details in Chapter 2 that follows.

Two salient results in the Plan are the following:

A. Research Programmes Targeting Strategic Priorities

Research programmes are proposed in the following priority areas:

- Information Technology (IT) deployment in the enterprise sector
- Web and Arabized software technologies
- Mathematical modelling including financial/economic applications
- Renewable energy resources (e.g. chemical, wind, hydroelectric, solar)
- Materials/basic sciences for innovative applications
- Sustainable management of coastal areas
- Integrated water management
- Technologies for new agricultural opportunities
- Nutritional food quality
- High quality research in subfields of molecular and cellular biology
- High quality research in clinical sciences
- Forging links between the practitioners of medical and health sciences and technology, social sciences and paramedical professions

B. Research Centres

Virtual and excellence centres are proposed as follows:

- A Virtual Centre for Instruments for Environmental Analysis coordinated by a properly staffed CNRS Centre for Marine Sciences should be established.
- A Nutrition Research Centre that could be hosted at one of the better equipped universities should be established as a national centre.
- A Medical Research Institute/Centre should be set up with a core in molecular and cell biology that would also eventually serve the research needs of other sectors.
- The Ministry of Agriculture should develop long term funding, staff and governance policies for the Lebanese Agricultural Research Institute (LARI) to enable it to participate in the STIP Plan and to play a central role in a wider and innovative agricultural system.

- A Virtual Centre for Material Sciences and Chemical Analysis should be established as a national centre, linked with all related capabilities and facilities in Lebanon to pool resources and optimize the benefits of expensive equipment and instrumentation.
- A Virtual IT Centre to serve the deployment of IT development and applications in industry and in the enterprise sector in general, as well as in the public administration sector. It is also to undertake needed research projects on web and Arabized applications technologies.

Endnotes

[1] See Chapter 6 of this document.

[2] It is important to point out that it is not enough to train and educate. Education and skills have to be embedded in structures that facilitate the integration of these skills into the requirements of the national economy; otherwise, the educational system merely feeds the brain drain. Industrial countries, such as the UK, now devote considerable attention to all aspects of skills and education. See for example: Nick Bloom, Neil Conway, Kevin Mole, Kathrin Möslein, Andy Neely, Caitlin Frost, *Solving The Skills Gap*, and/or *Summary Report* from the AIM/CIHE Management Research Forum Advanced Institute of Management Research, March 2004.

[3] An extensive amount of recent research has emphasized the critical importance of business networking on economic performance. See Luke Pittaway, Maxine Robertson, Kamal Munir, David Denyer and Andy Neely, *Networking and Innovation: a Systematic Review of the Evidence*, International Journal of Management Reviews, volume 5/6, Issue 3&4, pp. 137-168, 2004.

[4] Value added in the Lebanese industrial sector was below US$15,000 per worker. Little is known about value added in other sectors.

[5] See, William J. McDonough, *Reaping the Benefits of New Technology*, pp.7-11, in Susan U. Raymond (ed.), *The Technology Link to Economic Development*, Volume 787, New York Academy of Science, 1996. The national average for value added per worker in the US during 2004 was $85,000; at CISCO, the value added per worker in 2004 was $222,000, and sales per employee were $680,000. See: John Markoff and Matt Richtel, *Profits, not Jobs on the Rebound in Silicon Valley,* New York Times, 3 July 2005.

[6] It is interesting that researchers in the UK have attributed some of the economic problems of Britain to the shortage of skills at the leadership level of organizations and public policy. See the reference cited in endnote 21.

[7] The recommendations presented by CNRS are consistent with suggestions made at an earlier date by the Association of Lebanese Industrialists (ALI). See

the document entitled *Suggestions from the Association of Industrialists for the Execution of the Development Programme of Lebanese Industry,* July 2000, in which ALI recommends a wide range of measures to improve statistical, financial and legal services and recommends measures to support training, R&D, and all other measures relevant to the industrial sector.

[8] United Nations Industrial Development Organization (UNIDO), *Integrated Programme to Enhance the Competitiveness of the Lebanese Industry and its Integration in the Global Market,* 19 October 2000. Other relevant reports are:

- ALI reports from 2000, 2001 and 2002.
- Ministry of Industry (Beirut): *A Report on Industry in Lebanon 1998-1999, Statistics and Findings, 2002.*

[9] *Basic Sciences, Technology and Industry (TFI)*; Chapter 3 of the English Volume of this document.

[10] *Environment, Agriculture and Biological Sciences (TFE)*; Chapter 4 of the English Volume of this document.

[11] Mouïn Hamzé & Abir Abul Khoudoud, *Annual Report on Lebanese Agriculture,* pp.13, 2004, Beirut, 2005.

[12] *Objectives of a Lebanese S&T Policy Based on Socio-economic Needs (R&D Priorities).* Chapter 6 of the English Volume of this document.

[13] Mouïn Hamzé & Abir Abul Khoudoud, *Annual Report on Lebanese Agriculture,* 2004, Beirut, 2005.

[14] Mouïn Hamzé & Abir Abul Khoudoud, op.cit., pp. 13.

[15] Mouïn Hamzé & Abir Abul Khoudoud, op.cit., pp. 13.

[16] Mouïn Hamzé & Abir Abul Khoudoud, op.cit., pp. 25.

[17] Includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. See the Cooperation for the Arab States of the Golf website: www. gcc-sg.org

[18] Mouïn Hamzé & Abir Abul Khoudoud, op.cit., pp. 23.

[19] Mouïn Hamzé & Abir Abul Khoudoud, op.cit., pp. 17-18.

[20] *Medical Sciences and Public Health (TFM);* Chapter 5 of the English Volume of this report.

[21] All major industrial countries, whether small or large, undertake a considerable amount of R&D on their firms to identify the factors that are reducing efficiency, effectiveness, rate of innovation and labour performance with the aim to improve conditions. Needless to say, Lebanon needs to adopt similar policies simply because the nature of the factors that influence business performance are not universal varying from country to country. See, for example, Tim Edwards, Giuliana Battisti, Wesley Payne McClendon Jr., David Denyer, and Andy Neely, *How Can Firms in the UK be Encouraged to Create More Value?* A Discussion and Review Paper, Advanced Institute of Management Research, February 2004, ISBN No. 0-9546885-1-1.

[22] Hamzé & Khoudoud, op.cit., pp.21-2.

[23] This subject is fully discussed by A.B. Zahlan in: *The Arab Construction Industry,* Croom Helm, London, 1983; also published in Arabic by the Centre for Arab Unity Studies, Beirut, 1983; and *Acquiring Technological Capacity: A Study of Arab Consulting and Contracting Firms,* Macmillan, London, 1990. Also published in Arabic by Centre for Arab Unity Studies, Beirut, 1990.

[24] The subject has attracted considerable research in both Europe and the US. See, for example, Susan J. Harrington and Tor Guimaraes, *Corporate Culture, Absorptive Capacity and IT Success, Information and Organization*, pp.39-63, January 2005.

[25] In 2000, the Association of Lebanese Industrialists recommended the comprehensive improvement of Lebanese industrial statistical services.

[26] Peter Tindemans and task force members, *A Plan for a New Science, Technology and Innovation Policy for Lebanon,* Chapters 2-6 the English Volume of this document.

[27] Chapter 6 of the English Volume of this document (The full Task Force on Socio-Economic Analysis (TFSE) report can be provided at request).

[28] See for detailed description of the proposed STIP Plan: *a Plan for a New Science, Technology and Innovation Policy for Lebanon,* Chapter 2 of the English Volume of this document.

2. Proposed Plan for Science, Technology and Innovation Policy (STIP) for Lebanon

Basic Report

CONTENTS

OVERVIEW OF STIP CONTENTS

The **first section** of this chapter states the objective behind the plan for science, technology and innovation policy: its stakeholders wish to develop and use science, technology and innovation to help solve major Lebanese economic and societal problems, to strengthen Lebanon's regional position and to turn it gradually into a knowledge-based society. Formulated first in macro socio-economic terms, the challenges that Lebanon faces will clearly improve by bringing science, technology and innovation to bear upon them. A limited number of specific societal needs in three important domains – basic sciences, technology and industry; environment and agriculture; and medical sciences and public health – have been selected, offering great opportunities for Lebanon, when determined efforts are made in research, training and dissemination as well as in innovation.

A brief sketch of the situation in higher education and research in Lebanon is also given to provide the background for the initiatives that form the STIP Plan. However, without partnerships, dialogue and mutual understanding between governments and companies on the one hand, and scientists, engineers, universities and institutes on the other, the gap that inevitably exists between science efforts and their useful and tangible economic and social applications will not be bridged.

Not every approach to develop a policy for science, technology and innovation is equally appropriate. **Section two** describes the approach that was judged best suited for the circumstances prevailing in Lebanon. Against the background of what has to be built-up in the long-term in areas ranging from priority setting to reinforcing universities or research centres and strengthening policy making capabilities, the STIP Plan selects in paragraph 2.1 a particular set of activities and measures for Lebanon. Paragraph 2.2 then describes how these are part of a strategy that will gradually achieve a much more central role for STI in Lebanon in such a way that investments in STI will lead to recognizable economic and societal improvements, as well as a stronger environment for research. In this way, a self-propelling mechanism is created for further expansion of both investments in STI and the framework of the institutions for STI policies. "Policy by demonstration" is the phrase coined. The Plan has been prepared by three task forces of Lebanese experts with contributions from a number of international partners. A specific methodology has been followed which is described in paragraph 2.3. Members of the task forces and other persons involved are mentioned on page 13 of this document.

The elaboration of STIP initiatives for five years is to be found in **section three**. A number of research programmes are proposed, which should be accompanied by some major actions, including efforts in education and training, to improve the research system in Lebanon. The information and communication infrastructure needs upgrading. A variety of concrete proposals is made to strengthen the links between the research community (academia and research centres) and the private sector and public agencies, NGOs and civil society at large. The STIP Plan, however, also encompasses a few crucial enabling mechanisms, notably in the areas of indicators and statistics on STI efforts and in strengthening coordination between the key players in STI policy and in funding STI efforts. These mechanisms will further develop STI policies and increase the impact of STI on the Lebanese society and its economy. Paragraph 3.6 then provides a succinct overview of all the initiatives the STIP Plan comprises. Finally, the vital role of national and international partnerships, both as an objective and a means to implement the STIP Plan, is discussed in this section.

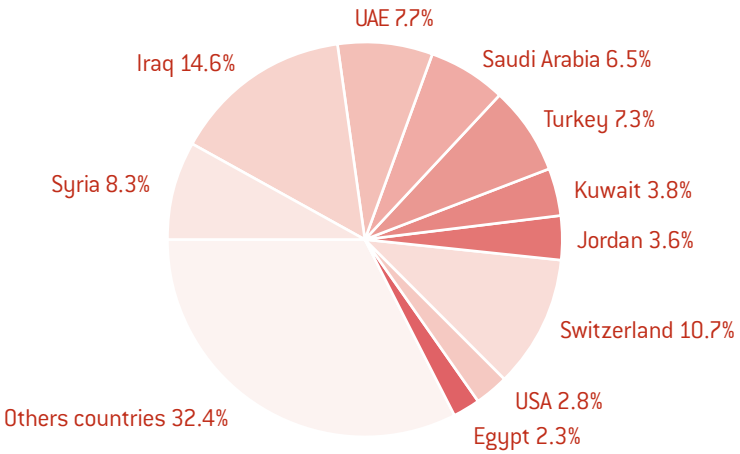
Section four concentrates on the implementation of the STIP Plan. First, an effort is made to describe the expected outcomes of the STIP Initiatives. To follow, the organization that needs to be set up for the Plan's implementation is put forward and the roles and responsibilities of the various constituent parts are established. An important responsibility among those concerns is the monitoring of the implementation progress and evaluating its impact and results.

An estimated budget is proposed in paragraph 4.3. As it is impossible to carry out all activities immediately, therefore the detailed STIP Plan of Action that follows identifies what steps should be set out and in which order, priorities proposed among the initiatives and finally what budgets will be needed in the various years of the Plan.

The execution of the STIP Plan requires a number of specified legal and administrative procedures. First, there is need for a general legal framework (law for a programme) that would allow budget planning for the five-year period of the STIP Plan (instead of being limited to one official fiscal year).

Furthermore, legislations are also needed, in effort to support partnerships between the main Lebanese actors (crucial to the execution of the STIP Plan) prototypes of agreements between the CNRS and its main partners have been formulated.

Exports by Destination (2004)



Source: Ministry of Trade and Economy, Selected Trade Indicators, http://www.economy.gov.lb/MOET/English/

1. Objectives, Stakeholders and Problems to Address

1.1. Objectives and Stakeholders

Lebanon runs the risk of losing out on two of its most valuable assets: (i) many of its young highly educated people move abroad or are unemployed; (ii) capital, too, moves abroad in search of profitable investment opportunities. The STIP Plan for a new science, technology and innovation policy for Lebanon addresses this problem through an attempt to create high quality jobs and investment opportunities. It should therefore be viewed in the context of the shared desire of the Lebanese Government, the private sector and organizations (such as the CNRS and universities) to strengthen the economy, improve the quality of life and help Lebanon join the worldwide trend towards becoming a knowledge-based society.

The objective of the STIP Plan is to increase and focus on the national efforts in science, technology and innovation in Lebanon, with the aim of strengthening and gearing the STI institutions towards the creation of high-quality jobs. Resulting in economic growth, the improvement of the quality of life and the strengthening of the position of Lebanon as a regional centre for high-quality education and research, economic development, trade, tourism and health care.

In particular, it identifies a number of specific opportunities in three areas: (i) basic science, industry (including services) and engineering, (ii) environment and agriculture, (iii) medicine and health care.

The STIP Plan, on the one hand also aims to strengthen partnerships between universities, the CNRS and research institutes and centres and, on the other hand, between organizations and private enterprises, other private organizations and public agencies. In addition, it purports to strengthen Lebanon's participation in regional and wider international networks in science, technology and innovation and to use those networks for the most effective and efficient implementation of the Plan.

The STIP Plan envisages that, firstly, all actors in the field of science and technology, including the CNRS, universities, research centres and institutes and individual scientists will commit themselves to its goals and its implementation. Respectful of every actor's autonomy, the Plan is a challenge and an invitation to jointly address both the opportunities for Lebanon to become a knowledge-based society, as well as the hindrances that should be overcome to achieve this objective.

However, the private sector, including the enterprises and the wider private organizations, as well as the government and other actors within the public sector, are key players to fine-tune its targets and to be actively involved in the implementation of the STIP Plan. The government has an especially critical role in creating the necessary conditions, particularly financial and regulatory conditions, to accomplish the economic and social potential implied in the activities of the Plan. However, while financial means are important, they are not the whole story. The STIP Plan also aims to represent a change in culture and in attitudes. Individual researchers, universities and institutes are invited to adopt new, or to reinforce existing approaches, based on awareness of societal needs, public accountability, rigorous research standards and entrepreneurship in one's own environment.

Though the Plan has been prepared under the auspices of the Lebanese CNRS, many specialists from universities and other national organizations have been involved in its development. It is, firstly and most importantly, a plan for Lebanon as a whole, addressing a number of key problems and needs specific to the country and, apart from the CNRS, all major national universities, institutes and research centres must play a key role for its successful execution.

1.2. Science, Technology and Innovation and Socio-economic Challenges in Lebanon

Modern societies are becoming knowledge-based societies. This in essence means that most or all of the production factors of economies and societies (to account for social production) including capital goods, human capital, information and knowledge capital and institutions become heavily transfused with knowledge. This is not just knowledge as accumulated experience, but science-based knowledge. Being part of the globalized world imposes developing and using such production factors transfused with knowledge. Education, research and innovation are key words for this process of transfusion and companies and governments worldwide invest heavily in them. The success of companies (i.e. at the micro-economic level) and economies (the macro-economic level), as well as the increase in individual freedom, the improvement in the quality of life and societal well-being (the social level) worldwide depends on this concept. To give just two illustrations: more than 30% of annual revenues in the manufacturing sector derive from new or improved products whereas, for more than a century, a steady GDP growth occurred in those countries that have accounted for, and still account for, most of the world's R&D investments.

Innovation is the result of technological change (a category used by economists to analyze economic growth) in combination with many other changes, such as in organizational design, management methods, marketing concepts, financial techniques and policy approaches.

Technological change and several of the other above-mentioned developments increasingly depend on scientific research in the natural, engineering and medical sciences. Today, research in social sciences and humanities has also become even more important than in the past.

Private firms, in particular, realize very well that innovation pays off. In almost all OECD countries, the trend of a business funding its own R&D, as well as public-sector R&D, has increased considerably from 1981 to 2001. At present, Lebanese private firms are, in general, small family businesses that are not very active in R&D. The STIP Plan, however, aims to change this perspective.

Governments should have the same impulse to improve through R&D and innovation the quality, productivity, cost-effectiveness and accessibility of a variety of services. But as firms will not invest much in basic and strategic research, governments are the main sponsors for it. Neither firms nor governments can afford to rely exclusively on accessing or buying knowledge produced elsewhere, since much knowledge is embodied in persons, procedures and organizations. Learning is necessary to appreciate, assimilate and absorb results from elsewhere. Neither companies nor countries can 'free-ride' on science developed elsewhere.

WHAT DOES THIS MEAN FOR THE VARIOUS SOCIO-ECONOMIC SECTORS IN LEBANON?

The relatively young demographic composition, the growth rate and the relatively high level of education of the Lebanese population make it appropriate and convenient to create attractive jobs in the high added value branches of industry and services. This is an urgent condition to improve economic productivity, reduce unemployment and combat the severe brain drain that the country has been facing for decades. Moreover, a better match of the choice of degree courses and the potential for job creation must be part of the policies adopted at the national level.

Reducing, and eventually eliminating, the huge trade imbalance requires substantial increases in export capacity. Given resource limitation or scarcity and relatively high wage levels and production costs, the only way to expand Lebanese exports is to move into higher added value production and services. That means, among other things, using technology more efficiently and in more creative ways, as well as improving quality levels in the productive (industrial and agricultural) and services sectors.

Revitalizing industrial manufacturing sectors and building up stronger professional service sectors are essential aspects of such a strategy. This can only be brought about by creating an environment that stimulates people, firms and institutions to make the most of domestic and foreign technology and information in creative and entrepreneurial ways.

Similarly, the agricultural sector, which suffers from low productivity, low added value, absence of private and public investment and is characterized by an output largely for domestic consumption, is in need of a leap in productivity, quality improvement and export performance. This will only occur by major inputs in R&D and entrepreneurial incentives, ensuring a proper balance with environmental sustainability.

With a clear strategy, the medical and health care sector, as well as related industrial and service activities such as the field of Information and Communication Technology (ICT), can become a strong pillar in the Lebanese economy. As these sectors are now permeated worldwide with ever more science and technology inputs, there is no way of achieving this aim without investing strongly in STI. Enhancing the knowledge level of medical and paramedical staff will help restrict a substantial economic drain through abuse in medications, medical procedures and sick-leaves.

Reducing energy and water inputs and making better use of available, or potentially available, energy, water and other natural resources would reduce costs to Lebanese industry and services, the government and consumers. It would, accordingly,

improve the export potential of national products. Achieving this is also impossible without dedicated and focused STI efforts.

Further development of the tourism potential, a traditionally important pillar of the Lebanese economy, not only requires entrepreneurial initiatives, but also the full use of rehabilitation and preservation technologies, inputs from the humanities and cultural sciences, ICT, marketing research and so on.

All these efforts will contribute to reducing the debt burden of Lebanon because they will help achieve high and sustained economic growth rates. They will improve the trade balance and offer investment options for huge amounts of capital that are now invested abroad by Lebanese banks. On top of that, developing and applying ICT and related scientific and technological fields, as well as marketing research are, nowadays, key factors for offering advanced, innovative and efficient financial services.

1.3. Societal Needs as the Basis for Lebanon's STI Policy for Five Years

The STI Plan intends to develop activities and policies in three separate domains whose issues are very important to the Lebanese economy and who have strong links to major fields of science.

The **first domain** concerns industry, including the services sector, basic sciences and engineering that are relevant to development in general. As industry is the key engine for economic development, it is only appropriate that Lebanese science and technology organizations and workers exert a determined effort to focus on its needs and define the respective underlying research, Human Resources Development (HRD) and dissemination activities.

Environmental concerns and challenges for Lebanon are important; the environment is thus the umbrella for the **second domain**. But since agriculture is of such pre-eminence in Lebanon, at the economic, social and environmental levels and its operations increasingly linked to, and often restricted by, environmental conditions, concerns and measures, it is a combination of environment and agriculture that spans the second domain. One challenge here will be to identify common activities based on the large commonality in the underlying science base and in opportunities open to them.

For any country, and in a regional context even more so for Lebanon, the **third domain** of health care and medicine will become more important for the future. This domain has characteristically been pervaded over the past decades by science and technology.

In each of these domains, many opportunities exist for the fulfillment of vital societal needs through the implementation of science, technology and innovation. Since not all of these societal needs can be addressed at the same time, a selection has been made of those needs that are judged to be particularly suitable and urgent.

1.3.1. Societal Needs in the Domain of Basic Sciences, Technology and Industry

The ambition is to address seven societal needs based on regional and national studies.

(1) Improve the management of energy, water and other natural resources by adopting an integrated and sustainable approach.

(2) Reduce industrial operating cost (e.g. energy, equipment and maintenance).

(3) Harness information and communication technologies for development.

(4) Harness and strengthen scientific research for development.

(5) Improve productivity in industry, increase technology and information content.

(6) Establish new industries suitable for development and job creation.

(7) Increase share in international trade and export performance.

Justification

The industrial manufacturing sector has been evolving in Lebanon since the fifties. Recently, it represented about 17% of GDP, for which in 1998 around 22,000 units were responsible.

Unlike several countries in the region, the Lebanese Government at no time sought the creation of large nationalized industrial firms. Instead, Lebanon has historically depended on import for most of its industrial and consumer goods. The industrial sector is composed almost entirely of small family-owned firms, employing on average less than ten people, converting semi-finished imported goods for the local market, or producing bulk items such as furniture, paper products and beverages. Value added industries are confined to a small jewellery-finishing sector and an equally limited fashion industry. Other local industries include certain perishable and delicate goods and processed foods. There is also a small market for time-sensitive and delicate goods, such as unprocessed food. For various reasons, including the reduced transport cost, most Lebanese manufacturing plants are located around population centres.

The industrial manufacturing sector in Lebanon faces several internal problems and challenges including:

- Small-sized industrial firms
- Labour-intensive production and investment
- Limited diversity in production
- Predominance of family businesses, characterized by monopolized decision-making
- Limited industrial investments
- High costs of production (including cost of raw material, energy, etc.)
- Generally poor quality of products, limiting their ability to penetrate foreign markets
- High transaction cost, leading to increase in opportunity cost (time, money)
- High energy intensity
- Limited resources at the Ministry of Industry (MoI) for proper management and support of the sector
- Limited control on the application of standards and norms in the sector

The above mentioned internal sector problems are accentuated by external ones such as:

- Poor competitive ability at the international market, especially with the high production cost and the irregular conformity to quality standards
- High competition in the Foreign Direct Investment (FDI) markets, especially in the absence of the appropriate environment in Lebanon to attract FDI
- Increase in regulations, resolutions and standards codes that the industry has to abide by since the signing of bilateral and multilateral trade agreements with various Arab countries, the EU and acceding to the WTO

Serious efforts by the private sector itself, and also the MoI, have been exerted during the last few years to further develop the industrial sector in Lebanon. Several analytical studies have been conducted and reports written, that were mostly in

agreement, on recommending the implementation of the following measures for the overall development of the sector:

- Improvement of industrial information and technical consulting services
- Creation of legal and organizational frameworks triggering incentives for industrial development
- Improvement of the industrial infrastructure
- Reduction of production costs
- Provision of sources of finance with attractive conditions
- Modernization of the sector
- Expansion of local markets for local commodities and the fight against dumping
- Development of exports
- Organization and administration of WTO negotiations from a strategic perspective

It is becoming urgent at this phase to mount sustained efforts to harness the potential of science, technology and innovation to the medium and high-tech industries in Lebanon.

Energy is a critical factor in this domain. High energy consumption is not limited to the manufacturing industry only, but covers all other economic and social sectors. Presently, Lebanon imports all of its fuel (by far the major source of energy) and primary energy consumption has been steadily increasing over the past few years. The use of solar energy to heat water unfortunately continues to be very limited in Lebanon, compared with other neighbouring countries such as Cyprus, Greece, and Jordan. According to one study in 2000 produced by the Lebanese Association for Energy Saving and for Environment (ALMEE) entitled *Le Solaire au Liban*, the installation of 400,000 solar heaters in Lebanon, over a ten-year period, would save electrical energy by approximately 8%, and consequently avoid the need to expand power production capacity by 100MW (saving more than US$100 million yearly as capital cost). At the same time, this would lower the energy bill by about $30 million over a ten-year period and would also reduce atmospheric pollution from thermal power plants.

R&D on renewable energy and on energy conservation are hence essential to the Lebanese economy. The establishment of the Lebanese Centre for Energy Conservation and Planning (LCECP) is a step forward in this direction.

Financial services constitute an important economic sector in Lebanon, with banking services in the past always ranking first in the region. This sector, however, is at present experiencing high competition from other countries in the region, such as Bahrain and Dubai. The sector is also encountering great technological changes worldwide, particularly in the areas of e-banking, new communication technologies (such as General Packet Radio Service (GPRS)) and new modelling techniques and operations research. The assimilation and adoption of these new technologies by the Lebanese financial sector is critical. By taking up these technologies and developing them further, Lebanese industrial companies would not only be serving the needs of the banking sector, but would also be creating higher value added industrial activities and products. Currently, billions of dollars are being invested by Lebanese banks outside Lebanon because return on investment is not high in the Lebanese market. At the level of the whole Arab World, it is estimated that more than one trillion dollars of Arabic capital is invested outside the Arab world.

1.3.2. Societal Needs in the Domain of Environment and Agriculture

The aim is to address four societal needs, which reflect national policy documents and international obligations to which Lebanon is committed.

(1) Stabilization (or prevention) of coastal deterioration through sustainable management.

(2) Integrated water management for an effective supply/demand balance.

(3) Grasping new agricultural economic opportunities.

(4) Improved nutritional food quality.

Justification

The coastal zone in Lebanon is already highly artificial and suffers increasing pressure from competing demands and interests threatening both its economic activities (production and tourism) and the conservation of natural habitats and biodiversity. This makes it increasingly difficult to cope with the requirements of the many international Memorandums of Understanding (MoUs) and protocols the government has signed and ratified. It is becoming increasingly urgent to mitigate the pressure on the coastal zone by finding sustainable and nationally acceptable solutions that are based on well informed, data-supported land-planning studies. Unfortunately, at present this seems difficult to achieve due to the limitation of reliable data, technically knowledgeable personnel and the appropriate regulatory framework.

It is estimated that the supply of available renewable water resources in Lebanon will sharply decline from 945 m^3 per person per year to an estimated 705 m^3 in 2025. In parallel, the levels of water tables will drop and seawater intrusion will be on the increase. At present, reservoir construction for better use of surface water is

ongoing. However, other less expensive and disruptive, small-scale solutions need to be further analyzed. The level and efficiency of irrigation needs to be seriously improved, especially after suffering badly during the Lebanese civil strife. It is also important that new and hitherto practically un-tested demand management measures should also be considered.

A major problem that is regularly encountered is the absence of a comprehensive database. This is the result of the disrupted collection of water resource data that is not easily accessible and poorly kept electronically. It is also affected by the absence of continuous monitoring and auditing and the limited availability of qualified personnel. More efforts could also be invested in the field of water recycling, where potable natural water could be an important industrial sector in Lebanon, particularly when considering the market of the Arab Gulf countries. This is especially true if competitive technologies are used for its production and packaging. The Ministry of Energy and Water Resources (MoEW) has a ten-year plan for water projects, with a budget of US$850 million over the coming ten years, with which the STI Plan should establish connections.

Agriculture remains an important economic sector in Lebanon, contributing to 12% of the national GDP and 40% of total workforce. Civil strife has had a severe impact on this sector, mainly by isolating farmers and producers from new concepts in agriculture, new improvements and innovations in production, packaging and marketing technologies and by limiting research to adaptive research. Accordingly, Lebanon's traditional markets were lost to new developing markets in the region and productivity declined to often 30-40% less than in developed Mediterranean countries. So far, little priority has been given to the sector by the government, which neither invested to make the sector comply with international agreements it ratified, nor anticipated the impact or opportunities of European import/export or market regulations.

Yet, Lebanese farmers demonstrate entrepreneurship and a remarkable willingness to take risks. Additionally, if properly used and exploited, the precious and unique natural resources within Lebanon could serve to be a major asset in the development of innovative high valued added products.

Food has evolved from a basic necessity for survival to an essential part of an individual's and a population's health and well-being. Improving food quality is a broad area ranging from human nutrition and food science to consumer protection and clinical studies. In Lebanon, the increasingly varied markets and consumer choices, coupled with upcoming safety concerns, make the need for a reliable reference body ever more urgent. Local and regional nutritional trend studies are lacking so far. While demand for education and reliable knowledge and products is on the rise and education programmes have been initiated, neither research on the

link between diet and disease, nor food and nutrition monitoring, has resulted in a reliable reference body. Additionally, no development of new products, according to specific requirements, is yet following suit.

1.3.3. Societal Needs in the Domain of Medical Sciences and Public Health

The ambition in this domain is to address the following societal needs:

- Resume the position of Lebanon as a regional leader in the field of medicine and health care through the improvement of higher medical and health science education and the quality and cost-effectiveness of medical and health care services.
- Create an environment conducive to a flourishing biomedical industry and services sector.

Justification

Even though Lebanon is a developing country, it ranks among the developed countries as far as the number of physicians and sophisticated medical equipment available per capita. Though expensive, the health-care system in Lebanon is well developed, with the availability of high-quality care. For those born in 1995-2000, the average life expectancy is one of the highest in the region, at 72.6 years, compared to 61 years in Egypt. Infant mortality is relatively low at approximately 28 per 1,000 live births, which is much lower than the Middle East average of 51. In the year 2000, there was one doctor for every 476 people in Lebanon, compared to 1,320 people in Egypt. Indeed, Lebanon has for many years been a regional leader in the field of higher education, medicine and health care.

However, civil strife has not left this lead unaffected. The economic importance of this sector at the regional level, which was high, has suffered greatly. At present, there are justified concerns as to whether the level of higher education and research in the field of health and medical care is sufficient; not only to maintain the present situation, but to reclaim the former position as a regional leader. Clinical research, for example, appears presently to revolve around relatively unimportant epidemiological or retrospective clinical studies. This is in part due to the nature of funding, usually from drug companies for promotional purposes rather than through drug development. This kind of research has a limited impact on the practice of medicine locally and abroad. A wider consequence of this has been that Lebanon has not been able to profit from the closer links that are emerging all over the world between the medical and health care system and the biomedical industry and services.

Lebanon remains poised to resume this function. Capitalizing on the country's proven history, coupled with future investment, should regenerate and expand its

ability to lead in the fields of health and medicine. An additional opportunity that should be seriously considered is that of 'medical tourism'. That which appears to be expanding in Lebanon and several other countries. Lebanon has the potential to combine high quality medical and health care with excellent tourism facilities.

It is well recognized that good quality teaching, medical and health care depends on the upgrading of knowledge. This is done mainly through quality research, the production of new knowledge and participation in international specialized meetings where the latest results of new research and their translation into teaching and health care are discussed. The improvement of technology mainly depends on the improvement of scientific research. For these reasons, investment in research is expected to improve higher education, medical and health care.

Such improvements in this sector will also create the potential for generating new companies and hence offer new jobs in the sector of biomedical industries. These industries have developed, on the basis of biomedical technologies, such as pharmaceuticals, biotechnology, medical devices, hybrid devices, biomedical engineering, diagnostics and health care-related information technologies. Lebanon too should tap in and develop the valuable source that is represented by a partnership with local and international biomedical industries. But in the area of biotechnology, for example, there is a delay between initial investment and profitability; hence it is difficult for capital markets to assess accurately the risk associated with early-stage technologies. For these reasons, and due to a lack of incentives that encourage such investments, the private sector under-invests in the commercialization of the results of basic and early-stage applied research. Currently, support for basic and clinical research from industry is negligible. Special effort should be made to provide clear and attractive information on the promises and the investment opportunities in medical research and technologies. Several mechanisms should be implemented to convince local industrialists using imported technology to invest in research and biotechnology.

The identification of the most important societal needs and their translation into priority areas for research in the domain of health and medical sciences is not as straightforward as in other domains. The Lebanese population conforms to the rest of the world with respect to medical and health needs. Although there are a few regional genetic and infectious diseases, the Lebanese suffer from diseases common to other parts of the world. While some of the specific problems arise from the developing nature of Lebanon, where ignorance and poverty may impact health issues, these too, do not easily lead to research priorities. The latter will have to depend more on where the highest quality is to be found and where industrial opportunities arise. The initial approach to this domain within the STI Plan must therefore be different.

1.4. Lebanese Higher Education and Research: Strengths and Weaknesses

Lebanese universities, research centres and science policy institutions, together with private enterprises and other societal organizations, face huge challenges in their attempt to grasp the opportunities in changing Lebanon into a knowledge-based society. When put against the background of their recent history, the importance and difficulty of this role stands out much more clearly.

Historically, Lebanon has been home not only to numerous higher education institutes, but also to some prestigious ones. The number of educational institutes in Lebanon has recently mushroomed. There is on average no shortage of well qualified academic staff, many of them being graduates of internationally renowned universities. Excellence in the rise of education in Lebanon can be attributed to a relatively young population with an abundance of indigenous talent, understanding of the value of higher education and a thirst for achievement through it.

The unique language capabilities among Lebanese scientists, but also among the population more generally, and the multicultural traditions, further strengthen this fertile soil. This results in a high percentage of educated individuals with a relative gender un-bias compared to neighbouring countries. Graduates from Lebanese universities have played a pioneering role in regional development.

When it comes to investing in research and science policy, Lebanon enjoys a relatively long tradition among countries in the Middle East. The CNRS is now more than forty years old; it has set up a number of research centres in several highly relevant areas. On the other hand, there are two active larger public research institutes that work closely with or under ministries, namely, the Lebanese Agricultural Research Institute (LARI) and the Industrial Research Institute (IRI).

There seems to be great potential in Lebanon for the application of science and technology: there is an adequate environment for development of individual initiatives; creative design skills are available; there is no lack of entrepreneurial and commercial drive; and the use of the PC and Internet are widespread.

Lebanese scientists who have moved abroad as a result of brain drain and absence of work opportunities, have kept their links to the mother country; something which represents a potential resource and an important network of professionals. Lebanon's exposure and interaction with various cultures is unique in the Middle East. The recent partnership agreement with the EU, which among others will allow for a grace period before full competitive conditions apply and the renewed international financial support, create a favourable environment for international support as long as the national situation continues to improve. One must also add

in this context that amongst other opportunities is the fact that the cost of quality research in the country continues to be relatively low.

The overall current situation, however, leaves much room for improvement for a variety of reasons.

The explosion in the higher educational system in Lebanon, for one, is not without perils. Recently, and in the absence of significant Ph.D. programmes and uniform academic standards, interest has been focused on degrees at the B.Sc., M.Sc. and MD levels. With levels exceeding local needs, a pool of unemployed or underemployed qualified graduates is being created. Moreover, most graduates are in the fields of the arts, humanities and theoretical sciences, with little emphasis on applied sciences. This over production results in a mass exodus of graduate students, leading to a significant brain drain. In some areas and circles it is reported that this problem was compounded by a regretful tendency among some male Lebanese graduate students to go abroad to escape military service, never to return.

Characteristically, very few institutions monopolize the bulk of scientific research in Lebanon and local funding for research is limited to very few sources, whether public or private. Additionally the most productive research is usually championed by dynamic individuals, based on their earlier achievements abroad, commonly with little or no institutional incentives. The lack of reward and punishment 'up or out', in many of the Lebanese universities, cultivates a culture of apathy. Internal regulations and bylaws concerning promotion, merit or workload are often outdated in many of the Lebanese universities. The absence of any meaningful collaboration between researchers or between groups working on related or similar topics, whether they are from the same or different institutions, adds to the severity of the problem.

Except for a few research-intensive institutions, critical mass is generally lacking. Fragmentation of human and financial resources is even increasing as more universities are being established, most of which cannot provide the proper conditions for research implementation. The increase in the number of universities may add no advantage to research and development in the country, as many of these universities cannot or do not have an interest in undertaking serious research and linking it to their teaching goals. Unfortunately, isolated researchers, even with the best qualifications, will soon lose their edge and fail to keep up with the advances of modern science.

Public research centres, on the other hand, perhaps with the exception of the IRI, were at a disadvantage, compared to universities, in recovering from the difficult period of civil strife and in profiting from the first period of national reconstruction.

Accordingly, there is an urgent need in these centres not only for competent staff and equipment, but also for repositioning in the light of new challenges whereby strengthening of networking and coordination with stakeholders becomes critical. At present, these centres are unable to play a significant role in extension service activities and technology transfer, nor are there any potential substitutes to fill this gap.

The lack of skilled technicians is another important factor hampering strong research units in both universities and research centres and it often hinders the exploitation of research in enterprises and public agencies. In some areas, however, there are adequately trained skilled technicians and analysts, but there are no jobs available, let alone career prospects. This problem is often linked to a not yet sufficiently developed technical infrastructure, ranging from the computer communications infrastructure to the power infrastructure, monitoring and analytical systems, etc. A situation accentuated by a poor supply of peripherals and poor maintenance.

The gap between university research activities and industrial needs is large. This is in part due to the poor and underdeveloped managerial and entrepreneurial skills among scientists.

The present weaknesses of the higher education and research systems in Lebanon are partly caused and further complicated by a prevailing dismal economic situation, with a huge national debt and subsequently a meagre budget for national research, despite a relatively high GDP compared to many countries in the region.

The outcome of the situation is a weak research output with few quality publications; and thus jeopardizing the chances of external funding from international competitive sources, or the capitalization on potential patents from important discoveries.

The creation of a research culture and a proper environment, in short, has not been forthcoming in Lebanon. The reasons for these shortcomings have to be defined and remedial action recommended. Here, one touches not only on matters related to a lack of funding, but also on the absence of a number of vital institutional conditions that together define and create a performing and vibrant research environment.

In this context, one important aspect concerns the linkage between teaching and research. Good quality teaching depends on good quality research and the production of new knowledge. Most of the universities in Lebanon are institutions for the automatic transmission of second hand knowledge. Research should be mandatory at the university level and research output should be used in the auditing process of universities and their teaching activities. For modern research, gathering qualified technicians, students, staff, including qualified mentors and modern

tools of information, together with modestly expensive equipment in well-defined structures, is much more important than massive investments in equipment.

The most productive years in a student's life are during the Ph.D. and Post Doctoral training. Structural solutions for the successful launching of Ph.D. programmes and the funding of Post Doctoral research fellowships should be implemented. The creation of teaching versus research tracks within universities or the reduction of the teaching and administrative duties of promising research scientists are options to consider.

Also important for the creation of appropriate research conditions and culture is the support given to collaborative research programmes in order to pool specialist expertise and the most advanced instruments and techniques. As research is now evolving at a high rate, various support mechanisms, including government regulations, should allow for rapid decisions (reduce red tape), quick customs procedures and easy international contacts.

All these measures will help attract back to Lebanon many prominent scientists now working abroad. Others can be enlisted in collaborative research programmes through funding of bilateral travel and support.

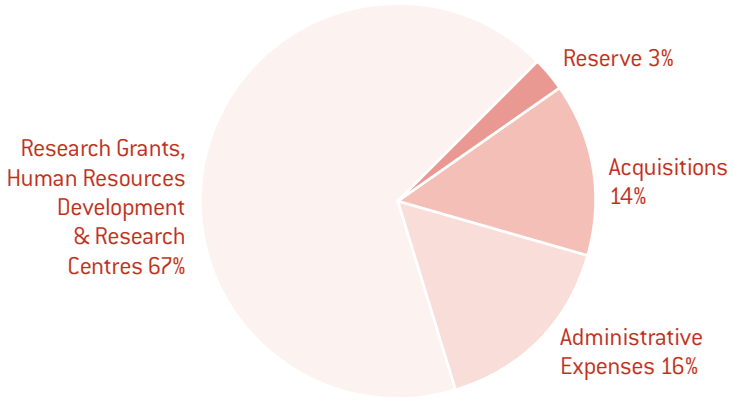
Successful modern research is further conditioned by critical mass, nationally or regionally. This requires the strengthening or the creation of institutions, independent or as part of universities, to become centres of excellence for a better use of available resources and to attract newcomers. They can also generate science-based innovations if partnerships with industry are established. Such centres, however, in addition to individual support schemes, require solid evaluation, auditing and quality assurance mechanisms.

1.5. Partnerships to Bridge the Gap between Science, Government and Industry

A major gap inevitably exists between scientific efforts and their useful and tangible economic and social applications. Bridging this gap certainly requires an effort from both governments and companies on the one hand, and scientists, engineers, universities and research centres on the other. Resulting benefits may not always be seen as directly linked to research efforts, as this certainly is a long-term process. Scientists, for example, have to think responsibly about priority setting and gear up to real socio-economic needs. Politicians are often right in assuming that science cannot solve all problems, but they should not underrate how much their range of interventions could increase as a result of scientific research. Preventing earthquakes, for example, will most likely not be within the scope of science. But knowing more about their causes, prevalence and impacts enables preventive

measures to be taken by governments, so that damage can be substantially limited, for example by appropriate construction methods. Building up such a mutual rapport is essential for policies on science, technology and innovation to be effective.

CNRS Budget Distribution (2008)



Source: CNRS, updated October 2008.

2. Strategy and Methodology for Developing STI Policies in Lebanon

2.1. Selective Focus for the STIP Plan

A long-term viable and productive STI system has foundations in many areas. Within these, the STIP Plan proposes to focus on the following:

2.1.1. Strategic Priorities

To achieve the greatest effect while making the most of the limited resources, actions of the various private and public enterprises and organizations should be aligned. To achieve this goal, it is important to try and agree on a set of strategic priorities, primarily for the economic and social sectors or activities and secondarily for science and technology.

There is certainly a growing awareness in Lebanon that, in the next several years, certain sectors in the economy should underpin economic development. Yet strategic focusing and priority setting, in the sense of formally agreeing on priorities

and on concentrating resources, are still insufficiently developed in several areas, including that of science and technology. This is due, at least partly, to the lack of appropriate means.

It is proposed that efforts should be concentrated on establishing a number of priority research programmes. By linking such programmes to the specific socio-economic needs of Lebanon, derived as much as possible from official government and industry statements, research efforts are visibly linked to Lebanese priorities and benefit at the same time from a structured implementation mechanism. Moreover, their longer-term nature and coherence indicate their strategic potential for Lebanese industry and society.

Stakeholder ownership of such programmes, and more generally, of science and technology efforts in Lebanon, must then be developed.

2.1.2. People, Universities and Institutions, Attitudes and Career Perspectives

At the basis of the exploitation of science and technology are factors such as availability of well-trained and skilled people and the capacity to auto-develop and absorb knowledge from elsewhere. This could be possible if one benefits from established universities, research centres and companies with a research culture.

Lebanon's position is widely recognized to be advantageous when it comes to education. However, it does not seem to be always properly focused, in the sense of an insufficient matching between the students' choices and the labour market, nor is it properly supported by strong and effective institutions and, most importantly, not sufficiently supplemented by adequate career perspectives and incentives. The result is often migration, which for some categories of adolescents is reinforced by other motives, such as a desire to escape military service or insufficient morale and dedication. This is quite in contrast to countries of comparable size where factors such as those add up to a vibrant system underpinning innovative efforts.

It is proposed that the STIP Plan concentrate on the following tools to create a proper research environment:

- Work on a clear commitment to increase research activities by more universities and on official standards and legislation to support this commitment. This translates into strengthening graduate education to better match labour market needs providing in turn more career perspectives. Professional or vocational training that is imperative to implement results of priority programmes will be considered as well;

- Start addressing the establishment of a number of new national centres of excellence and/or institutes; or strengthening existing ones that suffer from inadequate staffing and support, in order to achieve longer terms of sustainability for research and educational efforts;
- Work on creating incentive mechanisms to support collaboration across disciplines, universities and institutes, public and private sectors;
- Work on streamlining procedures to reduce red tape;
- Propose initiatives with more emphasis, for both institutions and individuals, on flexibility, autonomy, initiative, performance and accountability to improve the conditions under which scientists, engineers, universities and institutes have to work. A culture in which research performance counts should be institutionalized. This is a culture commonly linked to the 'hire', 'career', 'fire' and 'up or out' policies in place where ambition is and should be to do science.

2.1.3 Information and Communication Infrastructure

Achieving a productive STI system presently is not feasible without having a high-quality, cost-effective information and communication infrastructure. The value of this infrastructure extends beyond supporting education and research and the proper functioning of institutions. It also greatly enhances the ability of people and institutions to reach out and function in networks, which is a crucial process in the transformation of ideas and S&T into economic and social value.

The situation with respect to equipment, computers and information and communication within research institutions in Lebanon is rather varied, but on the whole should be strongly improved.

The STIP Plan concentrates on defining the scope of information and communication infrastructure for research and higher education that is well connected internationally, and on identifying the parties and resources needed for its implementation.

2.1.4. Outward Orientation, Partnerships, Mobility and Technology Transfer

One must make sure that education and research centres as well as institutions and the persons working in them adopt an outward-oriented approach. Strong interactions with private companies and public organizations are necessary, although they may have alternative roles to play.

Creating science, developing technologies and successfully elaborating on innovations does not often go well together, nor should they, as long as priorities are being discussed, technology transfer is organized and personnel mobility is stimulated. Partnerships between universities and the enterprise sector or government agencies, for example, needs to be built-up in order to properly evaluate technologies, discuss priorities and engage in mutual learning processes.

This should be considered in Lebanon's context where awareness of S&T is still unsatisfactory. Yet, industry in Lebanon is expressing readiness to act and participate in efforts to step up Lebanon's S&T base and its utilization by firms as well as to confront societal problems.

The STIP Plan will concentrate on a limited number of practical actions concerning technology transfer, product development, innovation, entrepreneurship, translational research and collaborative research projects, as well as on ways to engage the private enterprise sector together with other private and public customers of research; the latter being particularly important.

2.1.5. Systems of Innovation: Economic Clusters

It is important that interaction and cooperation between universities, research centres, enterprises, local and regional governments, chambers of commerce, schools or banks, venture capital funds or private investors are developed systematically. This will result in networks or systems of innovation and clusters of economic activity, that are now widely regarded as the fabric of innovative economies and societies. For even in a globalizing world where Information and Communication Technology (ICT) results in global technology flows, local, national, regional and international knowledge networks play a crucial role in shaping innovative success and social quality.

Institutional provisions are part of such systems of innovation and relate to such factors as transparent market conditions, intellectual property rights, etc. Entrepreneurship and taking initiatives are vital for these systems, which will be supported through such networks. Governments play a prominent role in creating the conditions for their successful functioning.

This STIP Plan favours a practical approach, implying that no specific actions, other than those focusing on more and stronger partnerships, are foreseen at this stage. It is assumed that there will be a natural stimulus to begin creating those networks.

2.1.6. A Properly Differentiated STI Policy

Several elements are essential to such an explicit STI Policy. Firstly, it is the formulation of policies (targets, measures, etc.) on the various aspects mentioned so far: human resource development, building strong universities, research centres, national research facilities and other services as well as creating an ICT infrastructure, providing incentives for mobility, technology transfer, university–industry links and dissemination; and secondly supporting the growth of clusters and systems of innovation. The formulation of such broad policies requires the development of proper coordination mechanisms at a high level; and their implementation is in need of adequate financing, not just for research and training, but also for innovation-related activities, using a variety of schemes, including tax incentives and support for venture capital.

The STIP Plan will concentrate on three issues:

(1) The institutional aspects of science policy will, for the next five years, build on the formal framework and the key actors in place, namely the CNRS. Institutional changes both in the formulation and the implementation of policies may eventually be necessary, but they have less priority now than concrete activities. However, the issue of coordination at the national level, also involving collaboration with international donors and sponsors who come in at this level, will be addressed.

(2) Actions are formulated to ensure the availability of (statistical) data and indicators.

(3) A plan is proposed to arrive at a more varied system of funding mechanisms, involving not only direct industry contributions, but also, government, fiscal and other incentives for industry, private foundations and other relevant institutions.

2.1.7. Proper Overall Economic Incentives and Other Government Policies

Finally, it goes without saying that a crucial condition that would allow all these efforts to successfully lead to economically valuable innovations and results is the existence of a favourable overall economic and incentive governance. Mechanisms to alleviate information problems, such as product standards, training certificates and credit reports, must be in place to ensure the effective functioning of markets. Here, the WTO membership and the EU Partnership Treaty should provide incentives to create these conditions in Lebanon. It should be noted that regulatory policies in many areas can either contribute to or impede innovation. In the course of preparing the STIP Plan, several examples have been identified.

No specific actions in this broader area are foreseen as part of the STIP Plan, but it is hoped that its adoption and implementation will encourage responsible parties to consider such measures.

2.2. A Strategy for Developing the STI Policies in Lebanon

The resulting strategy for developing a science, technology and innovation policy for Lebanon may be described as 'developing the STI Policy by demonstration'.

As was stated in paragraph 1.3, the focus is on opportunities in three important areas:

(1) Basic sciences, industry and engineering
(2) Environment and agriculture
(3) Health and medical sciences

Such a focus will allow for a much more tangible appreciation of the benefits of investing in STI. The emphasis is on concrete activities in the field of: (i) research, (ii) human resource development, (iii) dissemination, (iv) technology transfer and (v) innovation, which together lead naturally to more generic measures that strengthen the research environment and, accordingly, the STI Policy. Inviting cooperation and partnerships between different parties practically illustrates the network concepts that are crucial to modern STI Policies. Networks are effective means of making sure that R&D efforts are linked to societal needs, that R&D is linked to innovation, or that clusters of stakeholders, including universities, companies, government agencies do develop. Ensuring that these concrete activities are carried out in a fully transparent way through independent peer review, will, enhance the institutional capabilities and credibility of the bodies responsible for implementing STI policies.

It is envisaged that the presently proposed activities form a five-year stage. Funding is mainly provided through a Loi Programme, so that the actors have not only a framework, but also a financial perspective of a five-year scope.

After the approval of the first stage of the STIP Plan, the longer term strategic aim would be:

- After three years, extend the presently used approach to a few more areas by defining and funding activities comparable to those presently suggested

- To evaluate and modify, when needed, and subsequently formalize this approach after five years
- To incorporate this formalization in institutional reforms within the overall system of policy making, since the needs would have become clear and accepted and introduction feasible

2.3. Methodology

Over the past several years, the Lebanese National Council for Scientific Research (CNRS) has increased its efforts to initiate a new policy for science, technology and innovation for Lebanon. The basis for doing so is the legal mandate given to the CNRS. In April 2001, a report was written and presented by Dr. Peter Tindemans to the CNRS and UNESCO as a Plan of Action for the preparation of a Lebanese Science and Technology Policy that would be fully integrated into overall economic and social policies. The report was based on the available documentation and numerous discussions with relevant stakeholders in Lebanon during February 2001. For a variety of reasons, however, it was only in late 2002 that the proposed Plan of Action for the STIP proposal was approved.

It was then decided to elaborate the STIP Plan, essentially by some thirty Lebanese experts. Accordingly, and during the first half of 2003, the experts working in three task forces (domains mentioned in paragraph 2.2), namely basic sciences, industry and engineering, environment and agriculture, and health and medical sciences, presented their final reports. The Lebanese experts within each of the three task forces mentioned above were from universities, the CNRS and occasionally from the private sector or industry.

The three task forces worked independently, but closely, with Dr. Peter Tindemans and the CNRS, which assured the overall coordination and logistical support. The present consolidated plan draws heavily on the task force reports. It is important to note that substantial technical input has also been provided by UN-ESCWA. The STIP Plan hereby presented was supported financially by UNESCO and ALECSO.

Several working sessions were held with all three task forces with the aim of coordinating their work methodology. Each task force then identified, prioritized and selected a number of societal needs or ambitions. The justification for their selection came from the challenges and opportunities that Lebanon faces economically, socially or environmentally, and whose legitimization is to be found in government policy documents, stated economic priorities, international protocols, etc. Each societal need was then translated into highly relevant activities in research, education and training, as well as other activities strengthening the research

system, including activities in the area of dissemination, technology transfer and innovation. To achieve these results, while ensuring that the Lebanese situation had been properly taken into account and that the highest level of consensus among the experts had been reached, several commonly used techniques, such as Strengths, Weaknesses, Opportunities Threats (SWOT) analysis and Quality Function Deployment (QFD), were applied. The detailed analysis of each societal need in each domain can be found in the full task force reports which represent Chapters 3 to 6 of the English Volume of the Comprehensive Document. Many of the observations and findings in paragraph 1.4 on the present situation of Lebanese higher education and research are derived, for example, from the SWOT analyses of the task forces.

The resulting activities suggested within the task force reports, will not only significantly contribute to grasping the opportunities presented by the societal needs chosen in paragraph 1.3, but they will also result in a more vigorous research system. Together, they address the policy activities which presented in red boxes in paragraphs in 2.1.

Relevant to the nature of the domains studied, the emphasis on the type of activities is expected to differ accordingly. This explains why, for instance, research priorities in the health care and medicine domain have often been less explicit than in other domains, as this was justified by the fact that diseases are much less specific for Lebanon than issues related to the industrial sectors or environmental conditions. In the combination of quality and societal relevance, an even higher weight must therefore be accorded to quality.

3. The STIP Initiatives

3.1. Overview of the STIP Plan

As a preview and in order to provide the complete framework, all the initiatives that together will comprise the STIP Plan are listed here prior to their further elaboration in the remaining part of this section.

3.1.1. Research Programmes Targeting Strategic Priorities

In total, thirteen research programmes are proposed, to be implemented gradually:

- Five in the area of basic sciences, industry and engineering
- Four in the area of environment and agriculture, one being at the interface with the area of health and medical sciences
- Four (tentatively) in the area of health and medical sciences

3.1.2. Improving the Research Environment

To strengthen or create a proper research environment, the STIP Plan entails:

- Improving the functioning of universities. A commitment to research, new standards based on performance and auditing, Ph.D. programmes, Post Doctorate programmes and centres;
- Strengthening existing and establishing several new centres (environmental analysis, nutrition research, medical research, IT services, materials and chemical analysis);
- Incentive programmes to stimulate collaboration between people across disciplines, institutions, borders and the public and private sectors, etc. and with respect to shared use of research equipment;
- Streamlining of procedures;
- Measures to promote a culture of responsibility and performance.

3.1.3. Information and Communication Infrastructure

Here, two activities are proposed:

(1) Defining the scope and implementation plan for an advanced information and communication network for higher education and research.

(2) An incentive programme for innovative information products.

3.1.4. Linking Academia and Research Centres to the Private Sector, Public Agencies, NGOs and Society at Large

Exploiting and disseminating S&T in the STIP Plan is envisaged by a number of initiatives:

- Establishing a knowledge gateway industry in Lebanon
- Establishing (virtual) sectoral centres of excellence
- Setting up teams to support technical standards adaptation and adoption
- Entrepreneurship development
- Seed money provision
- Establishing new incubators
- Stronger representation of the outside world in steering committees and advisory boards
- Creating public and professional information units in four areas:
  (1) Coastal zone

(2) Water

(3) New agricultural opportunities

(4) Food quality

3.1.5. STIP System Aspects

Two areas for strengthening the STIP system have been selected:

(1) Getting better statistical data and indicators:

- STI Observatory
- Starting with a limited structured set of indicators

(2) Strengthening the role of the CNRS and coordination more generally:

- Role of the CNRS
- Stakeholder ownership for STIP Plan
- Coordination agreements with international donors and ministries
- Interdepartmental committee for STI Policies

3.1.6. National and International Partnerships

- The STIP Plan will not only benefit from, but should also explicitly aim to strengthen partnerships between universities, the CNRS, research centres and private and public sector enterprises and organizations;
- Address cooperation in the region and in the Arab world;
- The STIP Plan also must serve to incorporate Lebanese scientists and institutions in international networks.

3.2. Priority Research Programmes

The research programmes that follow have been selected because they, more than others, have the potential to tackle the societal needs identified by the task forces. Within each of these programmes are several themes and subthemes that would also need to be prioritized and most likely amended. Since it is not possible to start them all concurrently, the setting of this 'double prioritization' would require discussions with the relevant stakeholders. The resulting list of priority themes should then be binding. Accordingly, project proposals submitted in response to a call for proposals would only be eligible for funding if they fit these priorities and met all other conditions of quality and cooperation.

The programmes identified in the domains of basic sciences, industry and engineering, as well as environment and agriculture, have already been put in priority ranking by the relevant task forces. For the reasons mentioned above in paragraph 2.3, research programmes in the domain of health and medical sciences will be identified later, on the basis of the recommendations of a committee of international experts.

Moreover, in paragraph 4.2, it is proposed that the implementation of a particular research programme be preceded by an analysis of research activities and outputs, human resources and infrastructural facilities in the relevant areas and institutions of research.

3.2.1. IT Deployment in the Enterprise Sector

Increasing the competitiveness of local industry becomes an indispensable strategy when facing globalization and open markets. Making decisions based on information is currently a survival tool rather than a luxury. IT deployment in the enterprise sector, whether manufacturing, other industrial enterprises or the services sector, supports local industry in turning the challenges of the markets into growth opportunities. This is accomplished through various tools that should be customized to meet the selected priorities with local conditions. IT tools can address procurement, marketing, management, maintenance, design, production and control needs of industrial processes and products.

3.2.2. Web and Arabized Software Technologies

The ease of communication between various government bodies and the private sector is a key ingredient for effective public services that ultimately lead to a competitive economy. The rapid pace of development in web technologies will bring fundamental transformations in business processes and relationships. These technological changes will also redefine the nature of government and its relationship with its citizens. The impact of web technologies on governance in the digital economy and in the internal processes for the delivery of citizen-centred public services will be recognized by e-government. This transformation of government cuts across all aspects of the public sector from leadership, delivery of electronic public services, internal government operations and e-business, while retaining the flexibility to adapt to changing needs.

To maximize the benefits of such technologies, it is important that they are based, to a substantial degree, on Arabized software and software tools. Developing Arabized software and software tools will not only impact communication to and from the government, but will also offer many new management and job opportunities to companies in the private sector.

3.2.3. Mathematical Modelling Including Financial/Economic Applications

The lack of information based on system behaviour in the economic and finance sectors hampers effective analysis and planning for the socio-economic development of Lebanon. Along with this, the absence of true mathematical modelling of integrated systems (products/processes) remains an obstacle in attaining the required high quality standards and consistent products.

Mathematical modelling should aim to solve real-world problems with various applications, for example, financial, economic, geometrical and industrial. The use of computational and mathematical modelling helps the sectors of finance and economics sectors model interest rates, anticipate recession, predict growth rate, allocate assets in a portfolio, assess price options and edge currencies. Geometrical and industrial modelling gives strong support to numerically-controlled machining that helps to diminish the obstacles facing the current state of local industry.

3.2.4. Renewable Energy Resources (e.g. Chemical, Wind, Hydroelectric, Solar)

There is a need for every society to make the best possible use of its natural resources, stimulate economic development and improve livelihood conditions. So far, there are several underutilized opportunities, not only to reduce energy consumption, but also to produce electricity from renewable sources. The main focus is to cut energy costs, which while contributing to the preservation of the environment, would help enterprises in all sectors to become more competitive in local and foreign markets. A subsequent aim is to develop human resources in this field, as technical expertise and trained people capable of establishing enterprises that are competent in delivering competitive products in the field of renewable energy solutions. The Programme will be based on technologies developed abroad and their adaptation to the opportunities available locally; thus identifying the most suitable technologies for application in Lebanese enterprises and energy production plants and in niche markets for new products.

The main opportunities in this case are related to:

(1) Hydro-electric power, building on the fact that rivers in Lebanon mostly originate at very high altitudes.

(2) Solar energy panels, as commercial commodities as well as energy-producing devices and solar cell technologies.

(3) Advanced windmills for use inland.

3.2.5. Material/Basic Sciences for Innovative Applications

The use and functionality of all objects in our material world, whether products from manufacturing industry, handicrafts or even art objects, depends increasingly on

a fast-growing knowledge base of the material from which they are made. Their properties and characteristics, functions, transformations and substitutions are the subject of materials science and technology, in order to determine the performance and function of the products and objects we use. The production of the full range of materials, from construction through magnetic materials, to polymers, or surface coatings, down to biomaterials, is becoming science-based. Tailor-made functional materials are becoming easier to envisage as nanotechnology and science develop.

The research programme envisaged here has three objectives. It aims to develop solid materials science and technology base for use by enterprises. This base would be well connected to international materials science centres and thus to advanced developments in analytical and characterization methods and in rapidly developing fields such as nanoscience and technology. The programme will comprise applied research projects, which make their starting point in specific materials, and transformation processes, used in Lebanese enterprises and trades, in order to develop improved functions, new functions and products and more cost-effective manufacturing processes. Synergies with other STIP initiatives should be exploited, where developing biomaterials might be a case to be considered. Finally, the materials science and technology base, strengthened in this way, will be actively promoted to carry out research and development projects for domestic and regional companies.

3.2.6. Sustainable Management of Coastal Areas

The objective is to create the requisite data, knowledge and trained human resources that together will provide policy makers with the basic requirements for the implementation of a sustainable management system for the coastal areas. Working within the framework of the Lebanon Environment and Development Observatory (LEDO), the programme will thus be a significant contribution to its continuation.

The Programme will have three distinct research lines:

(1) Focus on the interaction between physical and biological systems through monitoring, modelling and impact studies.

(2) Focus on land use planning with a series of topics: impact of land-based activities, anthropogenic effects and mitigation, hot spots and areas of conservation, coastal processes and study of geodial elevations for protection, socio-economic impact of coastal activities (including tourism).

(3) Focus on the promotion of environmental studies using new technologies and techniques, such as environmental impact assessment studies, integrated coastal management techniques, GIS and remote sensing technologies.

3.2.7. Integrated Water Management

The objective is to increase the availability of water resources and improve water use efficiency, in addition to providing decision makers with the tools to do so.

The Programme will have four research lines:

(1) Focus on sustaining water sources which addresses the following topics: watershed management, assessment of ground water aquifers (local and shared), seawater intrusion and salinization of soils and aquifers, optimizing water use (quantity and quality) in the agriculture sector and forestry.

(2) Focus on increasing water availability including the following topics: snow water management, submarine fresh water sources (intervention management), rain water harvesting (studies and technologies), industrial wastewater effluents (innovative technologies for treatment and reuse), and forest management and reforestation.

(3) Focus on water conservation technologies dealing with: rainfall precipitation analysis, reclamation and recycling of sewage (studies and technologies), conservation technologies (agricultural, industrial, recreational, and domestic), and adaptation and use of new plumbing materials.

(4) Focus on water valuation incorporating socio-economic studies. It includes research topics such as: socio-economic impacts of water pricing, cost recovery systems, tariff protocols, privatization strategies, and cost-sharing programmes.

3.2.8. Technologies for New Agricultural Opportunities

The objective is to create the information, knowledge and technologies for new agricultural production opportunities with high comparative advantage for Lebanon and, accordingly, high business potential. These include using high quality plant propagation materials, local plant biodiversity, organic production technologies, sustainable agricultural production systems and improved rangeland management as sources for new high added value economic opportunities.

The Programme will have five research lines:

(1) High quality plant propagation materials: focus on their production under local conditions, use of modern technologies for disease diagnosis, infection prevention and eradication, as well as the relevant market studies for specific high potential crops.

(2) Medicinal, agricultural and industrial use of local plant biodiversity: this area addresses programmes to improve the productivity of local domesticated varieties and wild biotypes in the areas of breeding and the establishment of

gene/seed banks as part of national agro-biodiversity programmes, cultural practices and post-harvest technologies; development of new improved varieties using traditional or new biotechnological approaches; extraction of oils and pharmaceutical products; documentation, assessment and use of local traditional knowledge; biotypes and population dynamics; adaptation of modern technologies based on indigenous methods; nutritional value assessment; and market and consumer trend research.

(3) Organic production of plant and animal food products: this area deals with adaptive technologies for production, processing and commodity conversion of organic plant and animal husbandry products; their nutritional qualities; post-harvest technologies; and regional and international market studies.

(4) Sustainable production systems: this area focuses on the assessment of the efficiency of farming systems under various Lebanese conditions; assessment of new and local crop varieties; evaluation of pest control systems and components; and development of sustainable crop and animal production systems.

(5) Improved rangeland management: this area addresses the identification of local pasture plants and animals and assessment of their nutritive value, introduction of new high nutritive value pasture plants, rangeland protection systems and forage production.

3.2.9. Nutritional Food Quality

The objective is to create the information, knowledge and corresponding technologies to enable producers, food industry, consumers and government agencies to improve the nutritional quality of food products and diets, and to open up new economic opportunities.

The Programme contains three research lines:

(1) Nutritional characterization of locally produced foods: this involves the determination and labelling of nutrient characteristics, the development of standards on composition and common labelling criteria and the development of monitoring systems for quality assurance.

(2) Functional foods: this involves food fortification, dietary-linked, locally produced new food products, and relations between food and diet-related diseases.

(3) Safe and nutrient value preserving food processing techniques: this area focuses on modern technology in analysis and manufacturing as well as quality enhancing and nutrient value preserving technologies.

3.2.10. High Quality Research in Subfields of Molecular and Cellular Biology for Health and Medical Sciences

In the field of health and medical science, it has been agreed upon that a committee of international experts will be asked to identify the priority themes for research programmes. It has been suggested, however, by the task force of this domain, that there should be two programmes with appropriate subfields in each of molecular and cellular biology, as this area is now rapidly underpinning medical practice. This research will most likely be based in or coordinated by the Medical Research Centre that is proposed in paragraph 3.3.2.

3.2.11. High Quality Research in Clinical Sciences

Similarly, the working hypothesis of the international committee, as suggested by the task force, should encompass one research programme in clinical sciences as, for a modern system of health and medical care, it is indispensable to develop expertise and experts, not only in the basic medical disciplines, but also in clinical sciences.

3.2.12. Forging Links between the Practitioners of Medical and Health Sciences and Technology, Social Sciences and Paramedical Professions

The quality of health and medical care will get a strong boost if one succeeds in involving the various professional groups both in the development of knowledge and its incorporation in their professional practice. A smaller programme has been identified by the task force to address this issue. Its objective is to:

- Encourage and provide incentives for the creation and development of multidisciplinary research teams that integrate basic health and medical sciences with social sciences and clinical medicine.
- Encourage and provide incentives for the involvement of social scientists in health related research.
- Encourage and provide incentives for research in the fields of health promotion, prevention, rehabilitation and to identify alternatives to hospitalization.
- Encourage and provide opportunities and incentives for the involvement of paramedical personnel in modern medical and paramedical technologies.

3.3. Improving the Research Environment

3.3.1. The Functioning of Universities

Carrying out research programmes effectively, as identified above, cannot be accomplished without substantially strengthening Lebanon's research infrastructure. There is a general need for more universities to focus on research by

developing appropriate legal standards or other regulations, as well as by providing incentives.

It is worth repeating here a remark from the first section of this chapter on the objective of the STIP Plan. Improving the functioning of universities and creating or strengthening institutions and centres of excellence is not something that can be imposed. It can be stimulated and it is hoped that the STIP Plan leads to a financial impetus to do so. However, success depends upon the major parties involved and their joint responsibility to address these issues and to come forward with national solutions.

A substantial investment in research is necessary unless a university has the stated ambition of providing only Bachelor degrees.

The CNRS should make it a policy to provide research grants to universities only when there is a clear commitment and a realistic plan by the university concerned to provide complementary investments or building on them.

This policy should be reinforced by the Ministry of Education and, where appropriate, other ministries, legislating new standards for universities that ensure good quality education, teaching, training and research. These standards should involve certain measurable outputs. One important way of implementing such standards is through strict personnel policies. Decisions on hiring, promoting and tenure should be based on meeting the relevant set criteria that distinguish career tracks focusing more on research or on teaching. A system of auditing has to accompany the introduction of such standards, with consequences in cases of non-adherence to the standards, for example, in the overall financial support to a university or department. Adherence to such standards should also be used for evaluation of eligibility for re-licensure when appropriate, as in the case of schools of medical and public health and eligibility for research funding.

New university policies should be instituted and enforced for personnel management, performance evaluation and auditing practices.

The momentum of the new STIP Plan should be used to work on establishing more Ph.D. programmes in Lebanon. The three domains and the research programmes identified in the Plan should determine the areas where an effort should be made. Shorter advanced Master or Doctoral, or even Post Doctoral programmes might also be useful, especially as they have a shorter term impact. These shorter training programmes could certainly be considered for those areas that would facilitate value added product-oriented research. The relevant departments of a few capable

universities should consider launching joint Ph.D. or shorter Doctoral programmes using additional support under the STIP Plan. This will create a larger resource base which will also be more attractive for cooperation with foreign universities and external researchers. It would indeed be advisable to start by using a hybrid Ph.D. programme whereby foreign universities are granting degrees for research activity completed in Lebanon, under the mentorship of faculty members in various local universities. This is an area where cooperation with senior Lebanese researchers and faculty members abroad could offer great advantages.

- A number of new Ph.D. and other Postgraduate programmes should be established.
- The various research programmes identified above should also incorporate the funding of Post Doctoral research fellowships in Lebanon.

Similarly, these programmes should provide incentives to form centres of excellence in research or identify them where they exist, both in and outside universities.

3.3.2. Institutes and Centres of Excellence

Centres of excellence group qualified teams of professionals, personnel and trainees together with appropriate equipment, access to professional networks and modern tools of information. They can be part of one university, but could also operate as (partly) virtual centres involving two or more universities and centres affiliated with the CNRS. Senior professionals (as mentors) and researchers committed, partly or totally, to such centres could be given incentives and rewards in the context of the implementation of the STIP Plan. By being part of international networks of research, these centres of excellence could attract prominent and established scientists to Lebanon who would be able to develop research dynamics that would create opportunities for other researchers; thus helping to address the challenges of the brain drain. The STIP programmes should have built-in provisions to stimulate the formation or the strengthening of such centres of excellence.

In addition, specific initiatives to establish national centres in order to provide critical mass, an environment for excellence and conditions for efficient dissemination need to be considered. The important role of already existing institutions in reaching the STIP Plan objectives must also be stressed, with a concomitant effort in order to strengthen them.

Proposed centres of excellence (actual/virtual) would have a national mandate, open to research and more general paid services. These centres would be subject to scientific audit, certification and accreditation procedures whenever suitable.

Among the proposed national excellence centres are the following:

A Virtual Centre for Instruments for Environmental Analysis
There is a need in Lebanon for continuous environmental monitoring and analysis. With the relevant equipment that is presently available in Lebanon, or that should become available with the support of the current Plan, a Virtual Environmental Centre could be created to ensure the most efficient use of equipment and best quality assessment. University departments and institutes owning environmental monitoring and analysis would then be part of this centre. The coordination of the virtual centre could be handled by a properly staffed CNRS Centre for Marine Sciences.

A Nutrition Research Centre
It is also recommended that a Nutrition Research Centre be established in Lebanon; that can act as an ultimate referential body for the local community and market. It is foreseen to be a national centre relied upon by the Lebanese population and people in the region. The Centre would use the latest technology and international standards to assess local products and to provide information to the public.

At present, there is detrimental misinformation among the public in the region concerning diet-related disease, diabetes, hyperlipidemias, obesity and cancer. There is dire need to conduct research related to life-style practices, including diets and diet-related diseases. Public awareness should be enhanced to protect the population and produce solid and reliable research results.

While most Western countries have agencies, institutions, societies or centres overseeing food and nutrition issues, this demand is not adequately fulfilled in Lebanon and many countries in the region.

The Centre will address and conduct studies in a wide range of subjects, such as food analysis for nutrients, relationship of local dietary practices and disease, production of special foods, metabolic and clinical studies on diet – disease interaction and consumer science studies.

Indigenous and specialized expertise does exist in a few local universities in this regard. It is suggested that an arrangement be made between the government/ CNRS and the best equipped of these universities to host such a national resource centre that would be open to external researchers.

A Medical Research Centre with a Core in Molecular and Cell Biology
There is need to establish an autonomous research centre in medical sciences. It is suggested that this Centre be managed by the CNRS and be associated to different

research centres and universities in Lebanon. Its ultimate goal is to provide the proper mechanism and assist in the transfer of research and research culture to universities.

The proposed Centre should contain all necessary equipment for molecular and cellular biology research, as well as other facilities that respond to research needs in other areas in the medical and health fields.

The Centre should group a basic skeleton of qualified scientists, whose working conditions enable them to devote large portions of their time to research, as well as qualified research assistants or technicians. Several group leaders are required to maintain sustainable, productive and high quality research activity. Research programmes will benefit from visiting local and international expertise, especially Lebanese scientists working abroad.

The Centre should be led and managed by one or two senior scientists with established expertise and achievements in the fields of health and medical sciences.

It will host and provide services to Ph.D. students, Post Doctoral research fellows, junior and senior researchers and university professors.

It will create academic, industrial and community bridges and should, over time, be the focal point of a technopole for biomedical and health-related technologies. Its scientific activities should be reviewed by an international advisory board and audited more formally, on a regular basis, by an international panel of specialists.

A Virtual Centre for Material Sciences and Chemical Analysis

New material and research in material sciences is among the high priorities of the STIP. This would entail the establishment of a National Excellence Centre for Material and Chemical Analysis, equipped with the latest instrumentations and technologies. This Centre must be linked with all related capabilities and facilities in Lebanon (particularly the Lebanese Atomic Energy Commission (CLEA) labs and the proposed virtual centre for instruments for environmental analysis), so as to pool resources and optimize the benefits of expensive equipment and instrumentation.

A Virtual Centre for IT Services and Facilities

IT facilities and capabilities are growing fast in Lebanon, providing the country with opportunities for higher quality research and development programmes, particularly in Arabized software and web technologies. It is recommended that a virtual centre of excellence be established with a well-equipped central computational facility, available to all researchers in the field.

The CNRS Centres

The CNRS Centres, and especially those that have an important role to play in the implementation of the STIP Plan such as the Lebanese Agricultural Research Institute (LARI), are not yet in the appropriate position to do so. This is mainly due to the difficulties in recovering from the impact of the civil war and to their inability to catch up with modern technologies that are increasingly imposing the need to build-up a critical mass in order to benefit from economies of scale. Here, too, it is crucial to develop these centres as integral and constitutive parts of local and regional research, monitoring and disseminating efforts and to work in close association with universities. Beginning primarily with those centres that have to play a key role in the STIP Plan, the CNRS will develop long-term plans in conjunction with the implementation of the STIP Plan.

The Lebanese Agricultural Research Institute (LARI)

The Lebanese Agricultural Research Institute has played an important role in enhancing the standards in Lebanese agriculture, introducing new technologies, training personnel, developing strategies and supporting international cooperation. The STIP Plan can only benefit from a well-functioning LARI. It is clear, however, that the LARI, at present and for a variety of reasons, cannot fulfill those expectations. The Ministry of Agriculture (MoA) would be expected, as a necessary complement to this STIP Plan, to establish a long-term funding plan and appropriate staff policies, to enable the LARI to play its proper role in the implementation of the STIP Plan. It is important to define a framework for its governance as an effective and integral part of an agricultural system of innovation, comprising not just the LARI, but also universities and the extension service, thus imparting to it an ambition and the appropriate means to play a regional role. The CNRS should work with the MoA to make sure that the LARI can then benefit maximally from the STIP support.

3.3.3. Incentives for Collaboration Between People and in Using Research Equipment

When implementing the various programmes and activities proposed here, the CNRS should aim for added value by creating incentives for working modes that would give an additional boost to the Lebanese research system.

One aspect concerns intra or inter-university collaboration between established Lebanese scientists working in complementary fields.

A second aspect relates to coordination in the procurement and use of capital equipment for research; which should be accessible to researchers from all over the country.

Synergy between national and international funding sources is a third aspect here. This would require that national funding per project should be increased (and in the end across the board) to reach a level that is appropriate to attract further funding. Moreover, information on opportunities for extramural funding from competitive international sources should be more widely diffused and made better accessible to all. Other helpful measures could be to provide technical support in the application process and the provision of better matching funds in order to increase the chances for external funding.

Fourthly, collaboration with Lebanese scientists worldwide could be explored and stimulated further as there are many high calibre scientists active in all fields of science, social science and the humanities, especially in Europe, North and South America and Australia. The CNRS should take the initiative of making a survey of Lebanese scientists overseas, organizing workshops and setting up a database of Lebanese scientists in the Diaspora.

3.3.4. Streamlining Procedures

Several areas have been identified where research in Lebanon suffers from adverse regulations, procedures and other administrative practices. Examples here concern customs regulations with respect to the importation of equipment, biological and chemical species, substances and samples. Health-related regulations, with no consideration of the specific needs of research, intending to deliver its health improvement potential, only further complicates the problems. Another area that should be considered here concerns the restrictions with respect to international collaboration and exchanges that play a vital role in the future of Lebanese research and education.

The CNRS should draw up, together with the main universities and institutes, a White Book listing the major impediments. The Interdepartmental Committee, whose establishment is part of the STIP Plan (see paragraph 3.6.2), would then be the appropriate vehicle to seek resolution of these problems.

3.3.5. A Culture of Responsibility and Performance

Achieving high ambitions in a globalized knowledge-driven world makes it imperative to adopt certain rules of trade. It is a world where performance counts at the individual and the institutional level. Responsibility and autonomy are granted, but accountability and evaluation are demanded. Professionalism, initiative and transparency are necessary. Even though this may seem restraining to individuals and organizations, it is the society at large that will be rewarded. The STIP Plan will be utilized to implement such rules of conduct at several levels.

Universities
Concerning universities the first two issues of paragraph 3.3.1 address the crucial switch to a new culture. No separate action is necessary.

Research Centres
With respect to research centres and institutes, it will be important that the responsible parent organizations (ministries, the CNRS) establish similar arrangements regarding auditing, performance and careers to those mentioned for universities.

National Council for Scientific Research
The CNRS can in two or more ways contribute strongly to establishing such a new culture:

- The implementation of the STIP Plan should follow the principles of project management with clear goals, timelines, resources and management responsibilities. The procedures used, for example in calls for research projects, should fully guarantee transparency and objective reviews. Regular reporting and evaluation should be built into the implementation plan.
- Funding decisions under the STIP Plan, to begin with, should make adherence to the new principles mandatory, as mentioned in paragraph 3.3.1.
- The CNRS funding decisions and STIP management should follow the new policies of transparency and responsibility.
- The CNRS should continue vigorously to adopt similar rules in its internal operations and the procedures for its (non STIP) granting schemes.

3.4. The Information and Communication Infrastructure

3.4.1. A National Lebanese Research Network with High Speed Outward Connections

Over the past two decades, research and higher education communities all over the world have striven to establish computer networks that link them together. Broadband Local Area Networks (LANs) were constructed in buildings and campuses to satisfy the growing need for communication between researchers, professors, students and administrative staff in a given institution. While Wide Area Networks (WANs) links the various research and teaching institutions in a country. National research networks have been established to assist research, teaching, administration and innovation. These networks have always been the pioneers of novel services. High throughput connections to regional backbones and other

continents have led to an infrastructure that is being upgraded every four years or so to higher speeds and a wider range of multimedia services. The EU is heavily supporting these initiatives in Europe.

If aspirations to becoming an integral part of international networks and communities of scientists have to be achieved, then access to these services and the worldwide research community is essential for the researchers and their establishments. Information and Communication Technology (ICT) networks are no longer the privileged tools of advanced industrial countries; without them there is no way to accomplish the ambitions of the STIP Plan.

The UNESCO Cairo Office has planned to emulate the model of a national research network in the Arab region. The Lebanese project, with funding mainly from UNDP and the Office of Minister of State for Administrative Reform (OMSAR), with some cost sharing from UNESCO and the Lebanese University (LU), is focused on establishing a Lebanese University Network to connect about twenty campuses and sites, mostly in the Beirut area, as a first stage of a national network. Private universities and research institutions and centres should all be part of this network that provides high-speed and affordable connections to the outside world.

Establishing this network and improving the campus or site networks for various universities and institutes/centres is urgent. This task must be a joint effort of telecommunications actors in the major universities, the CNRS and public and private sectors. The momentum of the EU supported Europe-Mediterranean Information Society (EUMEDIS) project aims to connect Mediterranean partner countries to the European backbone (the present stage being called GEANT) offers distinct advantages in this regard.

It is, therefore, important to carry out a Quick Scan of the situation in Lebanon and on that basis propose solutions that must involve the creation of a permanent budget to upgrade the network regularly.

What can be done depends greatly on available funds. Experience in Europe and the USA shows, however, that the special circumstances of this community allow for different and cheaper solutions than are normally possible commercially. At present, the Trans-European Research and Education Networking Association (TERENA), which is also the main party for the EU Commission when it comes to defining and implementing the next stages of the European network, is ready to send a team to carry out such a Quick Scan.

3.4.2. Supporting the Development of Innovative Information Products

The Task Force on Environment and Agriculture has specifically identified several electronic information products that would be of great support to research, applications and product development. Examples are electronic support systems providing information on markets, pest and disease outbreaks, international regulations; expert systems for farmers, producers and extension agencies; growth simulation models and pest forecasting systems to assist integrated crop production; electronic support systems with information on global nutrition trends, innovations, markets, population diseases and processing technologies and so on. It is easy to see that similar ideas apply to the other areas, such as energy, materials or medicine and public health.

To complement efforts in improving the infrastructure for information and communication, the CNRS should establish a programme to support, on a competitive basis, these types of novel information products, primarily in, but not necessarily restricted to, the three domains of the Plan.

3.5. Linking Academia and Research Centres to the Private Sector and Public Agencies, NGOs and Society at Large

A variety of measures should be taken to encourage cooperaton between universities and research centres, on the one hand, to industry, public agencies, hospitals, environmental organizations, farmer organizations, etc.; and on the other hand, to tune education and research into to the needs of potential users. In the following sections industry will refer to the full spectrum of organizations in Lebanon.

3.5.1. Knowledge Gateway Industry

As Lebanon's industry consists to a very large degree of Small and Medium Sized Enterprises (SMEs), with as yet practically no in-house R&D capabilities, there is a need for an effective mechanism to provide information on expertise, facilities and equipment and ongoing projects in universities. This would enable industries to better identify and articulate their needs and would also link these needs to what is available in the country. This allows industry to benefit from university resources. Universities then profit from potential applied research activities financed by contracts or sponsored by industry, as well as from input into the educational process to make it less theoretical and to provide real-life problems for university R&D.

A two-fold mechanism could be established as a joint effort of the Industrial Research Institute (IRI) and the major universities: a database and Technology Promotion Unit (TPU) at each university and at the IRI. The database would contain all relevant

information on available resources and would be linked to a web-tool that allows industry ask questions, state problems, etc. Such a tool and database can then be developed as a matching tool between industry's needs and university resources. The TPUs would be small units to effectively link specific requests from industry to the university or research centre concerned, and actively provide information on such aspects as the potential to carry out product-oriented research and the possibilities of obtaining seed money support (cf. earlier in this chapter). Together they can support the Gateway by scheduled interactions, meetings, workshops, etc. The TPUs might also provide more specialized services. As an example, they might identify areas where, within Lebanese universities, projects can be carried out for international companies with limited funds from industry (e.g. in proteomics, structural genomics and drug discovery, pharmacogenomics, etc.), where a relatively small investment with Lebanese money is likely to be profitable in the short and long-term.

3.5.2. Virtual Sectoral Centres of Excellence

A particular category of centres of excellence should address the R&D needs of various industrial sectors in Lebanon. In addition, the centres would provide technical know-how and laboratory services to improve the competitiveness and growth of the industry. While the centres' priorities are actually derived directly from industrial sector needs, they must be implemented with the expectation that both industry and public interests are served. The national benefits include economic development, increasing productivity and value added, creating new job opportunities, improving health safety and environmental concerns and promotion of export.

The CNRS can start with existing sectors such as wine, clothes, shoes and furniture. The basis for future centres should be agreements between the CNRS, relevant local universities and relevant industrial associations or major companies to disseminate knowledge in various identified domains and to develop new knowledge and technology using industrial financing or co-financing.

These centres are referred to as virtual because they bring together, in a focused and coordinated way, dispersed resources. There is, however, no reason why occasionally there should not be a physical centre as the core of such collaboration. It might be a practical way of obtaining business or private sponsorship, provided the government is willing and able to provide fiscal stimuli for it.

3.5.3. Teams to Support the Adaptation and Adoption of Technical Standards for Lebanon

Export growth requires local industry to adopt international standards for products and processes in various sectors, occasionally after national or regional

modifications. Adhering to standards is one part of Quality Assurance (QA) systems. A campaign to promote standards and QA is not, of course, the responsibility of the CNRS or universities. But expertise in universities can be of great help to identify and clarify important standards which are not yet widely adhered to in Lebanon and to identify where local adaptation is necessary. This activity should be executed in coordination with the Ministry of Industry, the Industrial Research Institute and the Lebanese Standards Institution (LIBNOR). Activities carried out thus far by LIBNOR appear to be promising.

3.5.4. Workshops for Business Plan and Entrepreneurship Development for the Scientific Community

Transforming creative ideas into innovative products and useful solutions not only requires critical skills, but also most importantly entrepreneurial attitudes and a business drive to complement the expertise of scientists and engineers and the core of curricula of universities. A series of workshops should be organized as an inter-university effort under the aegis of several interested departments. To define the format and the contents of these workshops, the CNRS should take the initiative to establish a team consisting of a few professors with working experience at the interface with industry, a few from business departments and some outside experts with organizational experience in similar workshops (e.g. École des Mines, Paris). One of the more interesting offshoots of such an exercise could be the establishment of a degree course by one of the participating universities, whereby writing and implementing a business plan becomes a degree requirement. These workshops should target scientists and engineers (faculty and students) in the various higher education institutions and technical schools.

3.5.5. Seed Money to Enhance Commercialization

A special, initially small, funding initiative should be established to provide seed money for projects that aim to test potentially marketable ideas based upon earlier scientific work. Being the first stage, on a road that eventually would involve venture capital or company investments, it is worth exploring. The aim of the experiment is to find out if such an initiative indeed entices researchers to try and bring results of their research in a commercial trajectory. The CNRS could link this to Beirut Technology Pole (BERYTECH) and other similar science parks or incubators that might evolve, as these would provide the right environment to make available management, marketing, legal and other professional forms of support needed to guide a project from the research stage to commercialization.

3.5.6. New Incubators

Potential entrepreneurs and seed money to get things going are usually not enough. The BERYTECH initiative is the first example of a science park annex incubator in Lebanon. As more students or faculty members outside universities and institutes

would try to set up businesses, there would be a need for more incubators which may be specialized. The Medical Research Centre/Institute mentioned in paragraph 3.3.2 should, over time, become the focal point for a technopole for biomedical and health-related technologies.

It is suggested that the CNRS calls for a seminar assembling all parties concerned to try and agree on the best way forward: should there be more initiatives? Should the major universities try and first concentrate on working with BERYTECH? and so on. Such a seminar might result in a decision to commission a feasibility study or even the writing of a business plan along the lines of preferences.

3.5.7. Steering Committees and Advisory Boards

Universities, the CNRS and research centres should send out wider invitations to people from industries, communities and other relevant parties to sit on research boards, steering committees or advisory boards in order to have a broader range of outside views represented in research related decision making.

3.5.8. Public and Professional Information Units on Coastal Zone, Water, New Agricultural Opportunities and Food Quality

The research programmes described in paragraph 3.2 will bring together already existing information, as well as generate much new knowledge and information. Several individuals and organizations will show great, but different interest, in accessing such knowledge and information. In fact, it is important that they are provided access to knowledge and information as the targeted objectives of the research programmes (e.g. preventing coastal deterioration, improving water management, etc.) can only be achieved if all the different parties play their appropriate roles. This applies to a variety of professionals in government agencies and the private sector, to fishermen, farmers and their associations, to producers, consumers, tourists, companies, students, municipalities, communities and so on.

It is therefore essential to create the appropriate mechanisms to package, store and to make information accessible to these various users. The most natural solution would be to give the central or coordinating unit in each of the four areas chosen, in cooperation with the most relevant Ministry or Ministries, the task and the means of defining a programme of activities in order to disseminate information actively. The Task Force Report on Environment and Agriculture contains a wealth of specific examples of such activities.

For coastal zone and for water management, this would imply a role for the CNRS Centres for Marine Sciences and Remote Sensing, in cooperation with the Ministries of Environment, Energy and Water Resources.

For new agriculture, it would be the responsibility of the Agricultural Research Institute in cooperation with the Ministry of Agriculture and its Extension Service. For food quality, the proposed Nutrition Research Centre should assume responsibility in cooperation with the Ministries of Health and Agriculture.

It is evident that the approaches of these centres to the various tasks will differ widely. Yet there appears to be sufficient points of common interest, not only to define dissemination as an important leg of the STI Policy strategy, but also to define at least, the initial stages of its implementation scheme as a joint action.

3.6. STIP System Aspects

3.6.1. Statistical Data and Indicators

The inadequacy of data and indicators has been mentioned previously in a more general context. This is a concern that has also been expressed for S&T and the STIP. These data and indicators do not only serve the purpose of international comparisons, but their more important function is to guide and inspire policy makers in developing and targeting new policies, to provide a certain standard of performance and to enhance notions of accountability. An essential part of the STIP Plan must therefore be to develop a structured but practical approach to improve the situation substantially with respect to indicators and statistical information.

In various international bodies there is now an increasingly detailed experience with indicators in the area of STI. Organizations such as OECD, UNESCO, EU, several regional UN bodies and the World Bank have all greatly invested in establishing precise definitions for the activities of collecting statistical data, developing systems of indicators and encouraging their member states to collect underlying data in a reliable and comparable way. Three important trends have emerged in the past. Firstly, the earlier focus on input data, (public and private investments in R&D and higher education and the number of researchers), and output data (such as bibliometric and patent data) are being used increasingly. Secondly, the realization that innovation is the mechanism through which S&T delivers and that strong internally-connected 'national innovation systems' support innovation efforts, has now led to the consideration of systems of indicators that try to map innovation efforts and results. The third trend is to turn such indicator systems into composite indicators which enable helpful visualizations and comparisons at a glance of countries' performances. As a result, indicators that enable monitoring of some of the more complicated aspects of the relationship between STI capacity, national growth and competitiveness are now in use in all developed and most industrialized countries around the world.

The aim of the activities in the STIP Plan is to make sure that in a few years time Lebanon will have at its disposal reliable data on a minimum set of indicators which

is large enough to provide meaningful regional and wider international comparisons, and thus able to contribute to increasing accountability in the country. Many countries have, for that purpose, specialized STI observatories: units, sometimes in, but usually outside, the national statistical offices, that build on these data, add bibliometric and other data as necessary and provide the dedicated STI indicators on which policies rely.

The UN Economic and Social Commission for Western Asia (ESCWA) has provided in a background document (See Chapter 6) that is a very useful survey of the current state of play in Lebanon for a variety of STI indicators. It also intends to act as a hub for a regional network of national observatories and to assist in several ways, such as training for a Lebanese STI Observatory.

A Lebanese STI Observatory

Accordingly, it is proposed that a small team be established, as a separate unit at the CNRS, which would develop in a few years time into a Lebanese STI Observatory. With the support of ESCWA and the UNESCO Institute of Statistics in Canada, this could then become a viable and sustainable effort.

A Limited Structured Set of Indicators

The ESCWA Report mentioned above identifies a large number of potential indicators. In order to limit the efforts and to gain as much as possible from international comparisons, it is suggested that, as an initial framework, the two composite indicators that are now being used in the EU be adopted. The first highlights **investment in the knowledge-based economy**, the second **performance in the knowledge-based economy**. The first is composed of seven sub-indicators providing different measures of knowledge creation and knowledge diffusion. The second comprises five sub-indicators measuring the economy's productivity, S&T performance, output of the information infrastructure and the effectiveness of the education system.

Composite Indicator 1: Investment in the Knowledge-based Economy

Sub-Indicators	Type of Knowledge Indicator
Total R&D expenditure per capita	Knowledge creation
Number of researchers per capita	Knowledge creation
New S&T Ph.Ds per capita	Knowledge creation
Total education spending per capita	Knowledge creation and diffusion
Life-long learning	Knowledge diffusion: human capital
E-government	Knowledge diffusion: information infrastructure
Gross capital formation (excluding construction)	Knowledge diffusion: new embedded technology

Composite Indicator 2: Performance in the Knowledge-based Economy

Sub-Indicators	Type of Knowledge Indicator
GDP per hours worked	Productivity
European and US patents per capita	S&T performance
Scientific publications per capita	S&T performance
E-commerce	Output of the information infrastructure
Schooling success rate	Effectiveness of the education system

Source: http://trendchart.cordis.lu/scoreboard2003/index.html

3.6.2. The CNRS and its Coordination

Role of the CNRS

This STIP Plan addresses the responsibilities of, and identifies the activities to be carried out by, a large number of organizations, both in the public and private sectors. The CNRS is one of these organizations insofar as it manages research centres and operates as a grants-providing agency. But the primary capacity in which the CNRS has initiated this STIP Plan is in its lead role in developing the national science and technology policy. This role is defined in the Law of 1962 and consists of the preparation of the main directions of a national science policy, their translation into five-year programmes and the yearly allocation of research budgets in the respective chapters of the state budget of those ministries whose activities have research components. On all these matters, the CNRS, reporting to the Prime Minister, advises the government that is the decision maker. The mandate of the CNRS was enlarged in 2002 to encompass social sciences and the humanities. The circular, 17/2003, from the Prime Minister, reconfirms the coordinating role of the CNRS vis-à-vis the various government departments that fund research, hence underlining that the CNRS not only has responsibility for its own budgets, personnel and research centres, but also has a national responsibility and an obligation to work together with government funding parties and universities and other institutions, as well as industry.

The CNRS has the potential to be the pivotal player in the Lebanese STI serving the interests of society at large (industry, government departments, universities, institutes etc.). This should also be a guiding principle in complementing its role in the implementation of the STIP Plan.

Stakeholder Ownership of the STIP Plan

The STIP Plan must therefore be owned by all these stakeholders and be perceived as their common challenge in order to reap more benefits from science and technology. A number of factors and steps contribute to reaching this goal.

The identification of the societal needs in the current Plan is based on official documents, policy statements, international agreements, or on information obtained otherwise from external parties.

The Steering Committee formed by the CNRS to oversee the preparation of the STIP Plan and under whose aegis it will be presented to the government, assembles many of these stakeholders, thus adding to ownership. As the responsible for the CNRS, the Prime Minister is already in a position to express the backing of the whole government, which might be reinforced by affiliating this Steering Committee even more directly to the Prime Minister's office.

A number of stakeholder meetings, held separately for the private sector (including NGOs), international donors, government departments and agencies, will be organized to get more input and commitments to the STIP Plan implementation.

Coordination Agreements with International Donors and Ministries

As stipulated once more in the circular 17/2003, the CNRS has a coordinating responsibility. To ensure the input of other ministries and an effective and efficient implementation of the STIP Plan, a few formal measures have been identified.

One area in which it is of particular importance to strengthen is the coordinating role of the CNRS concerning relations with international donors, who usually invest large sums of money in Lebanese programmes that often have a research component. These donors commonly operate through various government agencies. Synergy between their efforts and the efforts now being elaborated in the STIP Plan will be mutually beneficial, as one commonly notes increasing dissatisfaction among donors and beneficiaries alike concerning lack of sustainability, assessment and follow-up, as well as duplication. Several examples displaying one or more of these concerns can easily be found, especially within the domains of the environment, health and also in the communication infrastructure.

The CNRS should conclude formal agreements with relevant international donors and the responsible government agencies not only to define their respective roles in the implementation of STIP programmes and activities, but to ensure synergy and to identify steps that contribute to the sustainability of international financial contributions through appropriate institutional mechanisms.

An Interdepartmental Committee for STI Policies

The formation of an Interdepartmental Committee for STI Policies is imperative to the implementation, further adjustment and follow-up of the STIP Plan. It is also important to the discussions on more general policy issues related to research, higher education, technology and innovation, including the yearly coordination of

the science budget allocations. This Committee would meet on a regular basis and would comprise of secretaries, or director-generals, of ministries and agencies most heavily involved in STI matters: the Ministries of Education, Industry, Finance, Health, Agriculture, Environment, Water and Energy, the Council for Reconstruction and Development and of course the CNRS. Its Chair could either be the Secretary General (SG) of the CNRS or the SG of the Prime Minister's Office.

3.7. National and International Partnerships

The STIP Plan must strengthen partnerships between universities, national research centres, institutes, private and public sector enterprises and organizations. This takes place at multiple levels. The Plan must be supported by the key players and its execution should also demonstrate this aspect of partnership. How this can be done for the main activities is indicated below.

Research Programmes: the General Approach

As a starting point, each programme should have a workshop involving key enterprises, organizations and researchers in the areas concerned. Its aim would be to discuss in more detail the themes and subthemes proposed, and it should result in identifying the priority (sub) themes that would be the subject of the first call for proposals. Depending on the subject, such a workshop might need some dedicated preparation; in the case of Information and Communication Technlogy (ICT) deployment in the enterprise sector, for example, in the form of a brief diagnosis and benchmarking of ICT performance of sectors. Next, it should be stipulated that joint teams from different universities, research centres and/or institutes and (where appropriate) industry carry out research projects. Moreover, as the programmes and their priority themes will, in many cases, reflect the real interests of identifiable outside parties, as a general rule, requesting a financial contribution of approximately 20% should be considered.

Each of the institutes and centres of excellence should be set up as a partnership. It may be between the two, three or four main universities and/or institutions involved; it may be between the CNRS and one or more universities; it could be between one (or more) university(ies) and private sector organizations, etc. How this will translate in the governance and the operations of the centres or institutes concerned will have to be considered on a case-by-case basis.

It is, of course, the very essence of activities, when speaking of university-industry linking activities and dissemination more generally, that they be based on partnerships, and be carried out within a close relationship between organizations and individuals in the field of science and technology and those to whom the activities are addressed. Appropriate modalities should be found for each case. Funding of specific proposals for linkage and dissemination activities must be made

conditional upon finding solutions which are satisfactory to the clients concerned. The final review of proposals must therefore give due weight to this aspect as well.

Similarly, the proposal to strengthen coordination at the level of the government seeks by definition to support the idea of a partnership between the various ministries involved. This could be followed up through specific Research Programmes (RP) or other activities being co-funded by the CNRS and one or more of these ministries (including international donor funds, as has been mentioned).

There is also an international component to the idea of partnerships. Pursuing such partnerships is important for several, but different reasons.

One pertains to regional cooperation. Attaining the required scale and scope for scientific and technological endeavours may point in the direction of collaboration in the region. Similarly, common regional problems (e.g. in the fields of water management, environment, transport, energy) denote such cooperation. In implementing the STIP Plan, the option of enhancing the impact of what one wants to achieve by seeking regional approaches, deserves serious consideration. It has to be done, however, on a case-by-case basis. The present situation in the region is not conducive to a wider geographical base for developing and implementing such STI Policies.

The situation does not appear to be any different when it relates to collaboration within the Arab world. It is clear that RP to develop web and Arabized software technologies would benefit greatly from collaboration with other partners in the Arab countries. For other activities, this is less obvious. So again, the potential for such collaboration should be evaluated when deciding to start the implementation of activities.

There are, however, more reasons to pursue international collaboration. Strong STI capabilities at present rest on two pillars: good facilities and resources in the country, but at the same time a solid integration in international networks. Concerning Lebanon at present, an additional aim is to try and use existing international contacts to accelerate and reinforce the intended effects of the STIP Plan. On the one hand, this relates to contacts with the very large community of highly qualified Lebanese scientists and entrepreneurs outside the country; on the other hand, the increasing number of international agreements and associations to which Lebanon has acceded, or will accede to, also offers numerous possibilities for benefiting from internationally embedding research and training activities. The EU Partnership Agreement is a case in point that should be utilized to the fullest. Existing Mediterranean partnership programmes, such as the Europe Mediterranean Information Society (EUMEDIS) Programme, already facilitates such collaboration.

Invoking the assistance of the Trans-European Research and Education Networking Association (TERENA) to work out plans for a Lebanese Research Network will, for example, make such a network effectively part of the European, and as a result, part of the global network infrastructure. Agreements in the wider region on water and other environmental areas are another example. There are at least four ways in which the implementation of the STIP Plan can incorporate these opportunities.

Firstly, some RPs most likely in the field of environment and agriculture, should be embedded as much as possible in broader international programmes under such agreements.

Secondly, it should be a funding precondition under the STIP Plan that the Lebanese partners demonstrate international embedding. What form this takes exactly, will depend on the particular activities. Sometimes, it will suffice if researchers on an individual basis show that they are well connected internationally. In other cases, one may require that an international team take part in the implementation. Bilateral financial support schemes may be instrumental in funding such collaborative efforts.

Thirdly, it should be possible to establish institutional links with universities or institutions abroad to implement some of the proposed activities. One example concerns the strengthening of graduate training. Using especially, but not exclusively, contacts with Lebanese scientists abroad. Attempts should be made to reach arrangements with a few foreign universities that may include offering courses in Lebanon, hybrid or dual Ph.D. programmes that foresee yearly stints of, for example, three or four months abroad, and so on.

Fourthly, one should aspire to involve foreign scientists in an advisory capacity in various research programmes and in the creation of institutes or centres of excellence. It would also be a good idea to involve scientists in such advisory roles from countries that have recently developed a technological base, and that are now taking the necessary steps to underpin it with a science base such as Greece, India or Taiwan.

4. Implementation, Monitoring and Evaluation

4.1. Expected Outcomes

The STIP Plan will have to lead to concrete results. Therefore an effort has to be made to identify some sort of a mechanism that enables one to measure, in as quantifiable a way as possible, how much progress is being made in meeting the societal needs and the underlying macro socio-economic targets mentioned in **Section 1**. Obviously, a one-off effort, even if it were a five year one, will not necessarily lead to

sustainable improvements. These can only occur if the STIP Plan gathers momentum and initiates a continuous effort in strengthening Lebanon's STI capacity. But even then, one should not overstate the case. Science, technology and innovation does not function in a vacuum: proper overall economic and social stimuli and conditions need to be in place, for example. Within the STIP Plan, expected outcomes will only come about as a result of several activities which are mutually reinforcing (such a RP and a Public and Professional Information Unit to disseminate results to companies, practitioners, agencies, etc.). Moreover, one cannot always easily quantify such improvements. Nevertheless, a determined effort is appropriate in identifying, prior to the start of execution of any particular activity, what the intended achievements might be. Part of the approval procedure of the Programme Management Unit (PMU) (see paragraph 4.2) must be to verify that satisfactory yardsticks have been identified. The PMU and the respective Primary Actors (PA) (see paragraph 4.2) should together establish what the most appropriate monitoring and evaluation mechanism should be in order to verify,at the end, that such yardsticks have been identified and targets have been met.

Usually, two distinct types of targets or yardsticks will have to be distinguished. Firstly, one should try, whenever possible, to formulate **overall performance targets** for sectors addressed by the STIP Plan. This can be done for the following sectors:

- Coastal management
- Water management
- Agriculture
- Food quality
- Energy production and use

Secondly, targets much more difficult to set concern matters dealing with **improved performance of the enterprise sector** that the STIP Plan hopes to contribute to. Therefore, for each STIP Plan activity, one should at least formulate intermediate or process targets.

These targets pertain to the intermediate output the activity aims to produce (e.g. the number of enterprise contacts made by the Knowledge Gateway Industry Lebanon). They are called intermediate because they are instrumental in attaining or contributing to the attainment of the final goals. If, for example, the aim is to reduce energy use in enterprises by 25%, the intermediate goal of a RP should be to develop new, or integrate existing knowledge in focused solutions for companies to

use. A dissemination activity would have as an intermediate or process target the number of enterprises reached with such information.

The distinction is particularly relevant in considering the macro-economic goals the STIP Plan addresses. They pertain largely to the performance of the enterprise sector such as: its export performance, productivity, employment opportunities and so on. Here, one can not usually do much better than to approximate final effects by some set of intermediary outputs.

Illustrations of targets that could be identified will be given for two activities. Some of these will be performance targets and the others of the intermediary type. A more comprehensive identification of such targets should be part of the preparatory phase for each of the activities (here reference is made to the Plan of Action in paragraph 4.4). As for the overall sector targets, the PMU should make sure that they are well established and agreed upon by all the PAs before the start of the implementation of specific activities.

Research Programme Information and Communication Technology (ICT) Deployment in the Enterprise Sector:
It is notoriously difficult to establish the final effects of this programme (i.e. productivity improvements, export increases, etc.) as a consequence of investments in ICT, let alone as a consequence of a RP in ICT. However, one can define useful intermediary indicators for increased competitiveness of enterprises, or at least the potential for it.

An applied RP that focuses on how small companies (with possible differentiation between sectors) can get effective, yet easy-to-use ICT tools to enhance both their internal business processes and better manage the external supply chain they are part of, will be considered effective if, for example:

- After three years, at least twenty-five students per year graduate at Masters level (by participating in applied research projects) in relevant degree courses
- After three years, an average yearly increase of 10% can be found in the number of enterprises in relevant sectors that apply either the internal business process improvement tools or the external ones, or both
- After three years, a similar 10% yearly increase occurs in the number of enterprises that are actively using the web as part of their business activities (sales, purchasing, etc.)

- After four years, three companies have been established, as a joint result of this programme and the RP on Arabized software, that produce Arabized software tools for internal or external business process improvements

Research Programme Integrated Water Management:
Performance targets for this programme could be:

- After five years, an increase of 30% in the expected available water supply in 2015 compared to the current estimates
- After five years, a reduction of water consumption per household of 25%, and of 50% for the enterprise and government sectors

4.2. Implementation Organization: Roles and Responsibilities

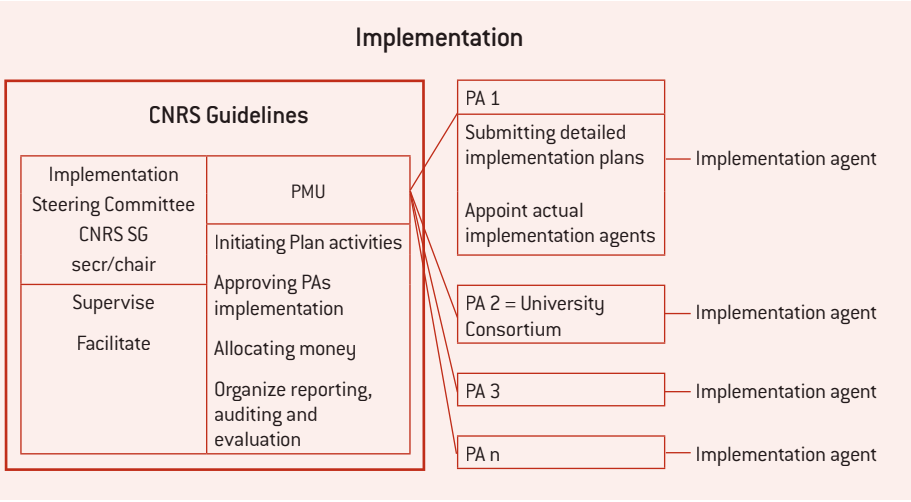
The STIP Plan should be implemented in a coordinated and comprehensive way to ensure that the largest synergy is accomplished and that reporting on progress is uniform. However, one has to distinguish between overall responsibility for implementing the STIP Plan and responsibility for the direct implementation of the various activities.

Thus the following structure is proposed:

Under the Secretary-General of the CNRS, a Programme Management Unit (PMU) will have overall responsibility for initiating activities as identified above, approving plans for them, allocating money to them, and for organizing and implementing a reporting, auditing and evaluation mechanism for each of them and for the STIP Plan as a whole.

For each activity or group of activities, an organization (which may also be a consortium of organizations) will be identified as Primary Actors (PA). It will be the PAs responsibility to put forward a detailed implementation plan and to set up the actual implementation agents. They will report to the PMU and receive the money granted from the PMU. The overview of activities (paragraph 4.3.2.) identifies the various PAs. A University Consortium comprising the main universities should be set up to have these universities bear joint responsibility for some of the measures proposed. The PA is defined as the main CNRS partner for the selected activity. The PA is to be selected among the most qualified national institutions in the specified field, particularly with regard to qualified expertise and dedicated equipment. The PA for each activity is to be assigned by the CNRS-PMU in consultation with the STIP Steering Committee.

The CNRS should appoint a special high level Steering Committee to supervise and facilitate the work of the PMU. It would be advisable to include several members from abroad, for example, highly respected expatriate Lebanese scientists or industrialists. The CNRS should establish financial, administrative and other guidelines, in consultation with the Steering Committee within which the PMU has to operate.



4.3. Budget

4.3.1. Preliminary Considerations

To estimate the budgetary implications of the STIP Plan, a few preliminary issues have to be discussed. The most important one concerns salary and equipment costs. So far, the policy of the CNRS has been not to reimburse salary costs when giving research grants, nor for that matter, the costs of equipment. As the present Plan aims to substantially increase the overall spending on STI in Lebanon (which amounts to saying that many new jobs have to be created in this area), there is no other way than to adopt the practice prevalent in all countries with serious STI investments of paying the full costs involved in carrying out research projects or activities that have been approved, including, in the end at least, some overhead costs. Of course, the auditing and career policies proposed for universities and institutions will result in scientific personnel not only having more time available for research, but actually spending it on research. However, these effects are difficult to quantify and one should not make the funding of specific RPs dependent on such relatively uncertain factors. More importantly, one of the underlying aims of the STIP Plan is to create a larger community of researchers 'bottom up'. That is, by creating a pyramid with a sizeable amount of Ph.D. positions, a smaller number of Post Doctoral positions, a still smaller number of junior and senior researchers, and so on.

A second point has to do with the availability of researchers. It will be impossible to spend immediately, from the onset, the full annual estimated budget. So, while the estimates per activity will be made for their maximal scope, there will in practice be a ramping up. The total annual budget will therefore be rather arbitrarily adjusted in the first three years.

4.3.2. Categories of Activities

The various activities of which the STIP Plan comprises can be distinguished in a number of categories as follows:

a. **Multiple activities:** these activities basically are, or resemble, research programmes. They will have the same implementation mechanism. Moreover, within each programme there are usually several projects of a similar nature.

b. **Policy measures:** these activities could refer to regulations that the government has to institute, or they could also concern internal regulatory or policy mechanisms within universities, the CNRS or other institutions.

c. **Quartermaster-type:** these are one-off activities that result in creating a new institution or unit, and rely heavily on the person who will be in charge.

d. **Implementation design:** these are activities concerned with the way other activities have to be implemented.

e. **Plan preparation:** activities for which it is first necessary to prepare a plan.

A full list of these activities follows in the table below. The table also indicates the year of actually starting the various activities. For a RP, this would mean the actual start of projects, or at least issuing a call for proposals; for a new centre, its actual 'groundbreaking'; for a new regulation, the moment of its entering into force. It is clear that before this can happen, preparatory activities are needed.

Multiple Activities	Primary Actor	Execution/Entering into Force
RP: IT deployment in the enterprise sector	CNRS	Y1
RP: Web and Arabized software technologies	CNRS	Y1
RP: Mathematical modelling including financial/economical applications	CNRS	Y2

RP: Renewable energy resources (e.g. chemical, wind, hydroelectric, solar)	CNRS	Y2
RP: Material/basic sciences for innovative applications	CNRS	Y3
RP: Sustainable management of coastal areas	CNRS	1 research line in Y1, 1 in Y2, l in Y3
RP: Integrated water management	CNRS	1 research line in Y1, 2 in Y2, 1 in Y3
RP: Technologies for new agricultural opportunities	CNRS	2 research lines in Y1, 2 in Y2, 1 in Y3
RP: Nutritional food quality	CNRS	1 research line in Y1, 1 in Y2, 1 in Y3
RP 1: On a theme in molecular and cellular biology in medical and health sciences	CNRS	Y1
RP 2: On a theme in molecular and cellular biology in medical and health sciences	CNRS	Y2
RP: On a theme in clinical/epidemiological sciences	CNRS	Y2
RP: Forging links between the practitioners of medical and health sciences and technology, social sciences and paramedical professions	CNRS	Y3
Supporting the development of innovative information products	CNRS	Y3
Seed money to enhance commercialization	CNRS	Y2

Policy Measures	Primary Actor	Execution/Entering into Force
Only universities adhering to importance of research are eligible for CNRS grants	CNRS	Y2
Institute new university policies for personnel, performance evaluation, auditing policies	Universities Ministries	Y2 or Y3

Streamlining procedures	MoEd, CNRS	Y1
Research centres and parent organizations to establish new personnel, performance evaluation and auditing policies	CNRS, Ministries, Institutes	Y2 or Y3
CNRS STIP management and funding decisions to follow new policies of responsibility	CNRS, Council of Ministers	Y1
Normal CNRS mechanisms to continue to adopt such principles	CNRS	Y1
Outside representation in steering committees and advisory boards	Universities, CNRS	Y1
A limited structured set of STI indicators to begin	CNRS, government departments	Already before Y1

Quartermaster-type of Activities	Primary Actor	Execution/Entering into Force
Institute Ph.D. courses	University Consortium	Y2
A Virtual Centre for Instruments for Environmental Analysis	CNRS	Y2
A Nutrition Research Centre	A main university	Y2
A Medical Research Institute/Centre with a core in molecular and cell biology	CNRS	Y2
Knowledge Gateway Industry Lebanon	University Consortium	Y1
Virtual IT Centre	CNRS	Y1
Virtual Centre for Material and Chemical Analysis	CNRS	Y2
Virtual Sectoral Centres of Excellence	University Consortium	1 in Y1, 1 in Y2, 1 in Y3

Teams to support the adaptation and adoption of technical standards for Lebanon	Universities, LIB-NOR, IRI	Y2
Workshops for business plan and entrepreneurship development for the scientific community	University Consortium	Y2
New incubators	CNRS, university Consortium	To be decided in Y1 on basis of detailed feasibility study
Public and professional information units on coastal zone, water, new agriculture, food quality	CNRS Centres for Marine Sciences and Remote Sensing, LARI, Nutrition Research Centre	1 in Y2, the other 3 in Y3
A Lebanese STI Observatory	CNRS	Already to be initiated before Y1

Implementation Design	**Primary Actor**	**Execution/Entering into Force**
Include Post Doctoral grants in STIP support mechanisms	CNRS	Before Y1
Include institutional support to emerging or existing Centres in STIP support mechanisms	CNRS	Before Y1
Built-in incentives for collaboration and synergy	CNRS	Before Y1

Plan Preparation	**Primary Actor**	**Execution/Entering into Force**
A national Lebanese research network with high speed outward connections	CNRS, University Consortium	Before Y1

4.3.3. The STIP Budget

A number of assumptions have been made in formulating the estimated STIP budget. The first assumption relates to the total salary costs of the various categories of personnel involved in the execution of the STIP initiatives.

A second assumption relates to the (average) size of the RPs (LBP 375 m (million) per year, respectively LBP 150 m for the two incentive programmes concerning information products and seed money). For the centres that the STIP Plan proposes to establish, the Medical Research Centre will eventually acquire an annual budget of LBP 900 m, which includes the cost of carrying out one of the RPs in medical and health sciences. Four other centres are budgeted at LBP 300 m per year; the sectoral centres of excellence, at LBP 75 m as they will depend largely on existing expertise, will focus less on expanding capacity and will have to generate substantial contract or sponsor income. For all the other, smaller scale, activities only a total figure for each is estimated.

To arrive at the budgets for the successive STIP implementation years, two aspects need to be taken into account.

- Not all activities start in the first year, as indicated in paragraph 4.3.2
- Most activities will not start at their full scope and size, as it will take time to hire people, buy equipment, etc.

Among the assumptions made to reach the STIP budget are also detailed assumptions on the build-up rate, particularly for the RP and the research centres, which result, in both cases, in first-year budgets of about half the full-scope budgets.

As will be explained in more detail in the Plan of Action in section 4.4, most activities need a preparatory phase prior to the start of implementation. The cost of these preparatory activities is assumed to be small and has been included in the budgets of the various years. However, for those activities that should start at the beginning of Year 1, and those that should preferably even precede the completion of the full formal decision process, a small Preparatory Budget for Year 0, of LBP 250 m, is necessary. The Plan of Action assumes that when the Cabinet decides to approve the STIP Plan, prior to parliamentary approval, it would decide to make that Preparatory Budget available.

Finally, three major initiatives have not been budgeted separately. With regard to the Ph.D. programmes, part of the costs can actually be considered to be included in the costs of relevant RPs for the STIP. Other parts, however, are intricately interwoven

with the general costs of universities, the way these are financed and the impact the proposed new university policies might have on all this. It is, accordingly, impossible at this stage to come forward with concrete estimates of additional costs. Secondly, as the precise nature, scope and costs of new incubator initiatives are not yet clear, these cannot be budgeted either. Thirdly, the Higher Education and Research Computer Network can only be budgeted after a concrete Plan becomes available, on the basis of the outcome of the Quick Scan that the STIP Plan proposes to undertake urgently.

Additionally, management costs have to be included. A figure of 5% has been assumed which reflects international practice. The resulting overall estimated STIP budget will then be LBP 50 billion for the six-year period, including the Preparatory Year Y0; to be readjusted according to the list of approved activities and progress achieved.

4.4. Plan of Action

This Plan of Action describes all the steps that need to be set, successively or in parallel, to implement the STIP Plan. Three major areas need to be distinguished.

(1) First, there are those steps necessary to get formal approval by the government (and the Parliament where necessary) of the STIP Plan, the budget, the mandates and the coordination structures at government level.

(2) Second, the implementation organization has to be established, together with cooperation agreements between the major parties.

(3) Third, a detailed plan needs to be prepared, and the individual activities that comprise the substantive part of the STIP Plan successively implemented. For the first implementation year, a list of priority activities is presented. For any subsequent year Y, such a list, and the entailing budget, should be established early in the preceding year Y1, so that any preparatory activities will be completed before the year Y commences. In fact, the Work Plan for year Y should comprise all the preparatory work to be carried out in that year.

4.4.1. Formal Steps

In the table that follows, it should be understood that approval usually implies approval after modification.

When	Number	Action	Responsible
Month 02/ Year 0	I.1	National seminar • Approval STIP Plan • Approval priorities for first implementation year	CNRS
04/Y0	I.2	Submission to Cabinet. Request to: • Approve STIP Plan • Provide small additional budget for preparatory activities in Y0 • Provide CNRS with mandate • Agree on Loi Programme and budget • Establish Interdepartmental STI Committee	CNRS
06/Y0	I.3	Cabinet approval, submission to parliament	Prime Minister
06/Y0	I.4	Make Preparatory Budget available	MoF
11/Y0	I.5	Parliamentary approval	Parliament
01/Y1	I.6	Make first Implementation Budget available	MoF

4.4.2. Building up the Implementation Organization

When	Number	Action	Responsible
04/Y0	II.1	Identifying Head of Programme Management Unit (PMU)	SG CNRS
06/Y0	II.2	Establish PMU (Head & two more people)	SG CNRS & Head PMU
06/Y0	II.3	Establish steering committee from stakeholders to supervise STIP Plan implementation	CNRS
06/Y0	II.4	Conclude cooperation agreement between CNRS and main universities (LU, AUB, LAU, USJ) Includes: • Principles of partnership and cooperation (e.g. in Ph.D. programmes, in establishing new centres, Knowledge Gateway, etc.) • Identifying Primary Actors (PA) • Outside representation in advisory boards, etc.	CNRS

06/Y0	II.5	Conclude cooperation agreement between CNRS and LARI, IRI includes identifying PAs	CNRS
07/Y0	II.6	Establish responsibility and reporting document on the responsibilities and mutual relations of PMU, PAs and Implementing Agents (IA)	PMU
07/Y0	II.7	Establish administrative guidelines for spending the Preparatory Budget for Y0	PMU, CNRS
07/Y0	II.8	Identifying IAs for each of the activities in the first year priority list	PAs
07/Y0	II.9	In particular, CNRS should set up IA structure for implementing the various research programmes	CNRS (as PA)
10/Y0	II.10	Conclude cooperation and coordination agreements with ministries and with international donors/organizations	PMU, CNRS
10/Y0	II.11	Establish implementation protocol (including eligible costs, administrative guidelines and monitoring and evaluation protocol) for STIP Plan implementation	PMU, CNRS
10/Y0	II.12	Establish Work Plan Y1, with preliminary plans for Y2 and Y3.	PMU
11/Y0	II.13	Workshop with all PAs and IAs to discuss implementation protocol, agree on Work Plan Y1	PMU

4.4.3. Preparation and Implementation of STIP Activities

Preliminary Activities

Several activities can be carried out prior to the setting up of a PMU, or even approval of the STIP Plan, as they will have a value of their own, even when funds for the eventual implementation of the prepared activities would only come later.

These concern:

- Overview studies of research activities in Lebanon in the three domains considered as a basis for the implementation of the STIP Plan

- The Quick Scan of needs, dimensions, international embedding and an implementation plan for a Lebanese Higher Education and Research Computer Network
- Establishing the core of the Lebanese STI Observatory

With respect to the overview studies, two types of analysis are needed.

(1) An analysis of research activities and research outputs in Lebanon in the last five years:

- Quantitative analysis and tabulation of the distribution of funded research proposals submitted to the CNRS, based on the assumption that research applications to the CNRS constitute a representative sample of research in Lebanon
- Quantitative and qualitative analysis of the research outputs (list of publications in peer-reviewed international journals)
- Identification of the sources of research funding as well as the institutions that have received research funding in the past. (Amount of extramural and total funding, when available)

(2) It is also important to identify what human resources and infrastructure facilities exist in Lebanon in the various fields included in the STIP. This mapping will include an estimate of:

- The number of established researchers
- The number of recent recruits in various relevant research fields
- Major equipment and its distribution
- The number of qualified engineers, technicians and other personnel
- The number of trainees (MS, Ph.D., Post Doctoral)

Preparatory Activities

As soon as there is approval by the Council of Ministers, one should start preparing for the implementation of the Y1 priority activities (paragraph 4.3.2) with the Preparatory Budget that will be available by the middle of Y0, if the planning mentioned above is met.

Most of these activities are evident, but there is one that needs further explanation. In the field of health and medical sciences, and as previously indicated, a committee of international experts is expected to define the three or four major research areas that should be the focus of Lebanese researchers in health fields in the next five to ten years. It is proposed that the data generated through the analysis of research activities and outputs and the mapping of the human resources and infrastructure facilities, serve as a basis to be used by this committee to define these major research areas.

The recommendations of the committee of international experts should lead to the:

- Definition of the basic structure of the Lebanese National Medical Research Institute/Centre that may house the basic core of full-time researchers and technical staff and conduct some research on some of the proposed projects
- Formation of the major research groups based on the existing research activities and priorities in the various institutions

Resulting Y1 Action Plan for Substantive STIP Activities

When	Number	Action	Responsible
03/Y0	III.1	Quick Scan and Implementation Plan for Lebanese Higher Education and Research Computer Network	CNRS
04/Y0	III.2	Analysis of research activities and their outputs, human resources and infrastructural facilities in basic sciences and engineering	CNRS
04/Y0	III.3	Analysis of research activities and their outputs, human resources and infrastructural facilities in environmental and agricultural sciences	CNRS
04/Y0	III.4	Analysis of research activities and their outputs, human resources and infrastructural facilities in health and medical sciences	CNRS
06/Y0	III.5	Setting up the core of Lebanese STI Observatory	CNRS
07/Y0	III.6	Establish the task force to prepare Knowledge Gateway Industry Lebanon	Joint universities, PMU, IRI, ALI
07/Y0	III.7	Identify three areas for (virtual) sectoral centres of excellence, after which the respective IAs will start preparations	Universities, ALI, PMU
09/Y0	III.8	Establish committee of international experts on health and medical sciences to advise on priorities	CNRS, PMU
09/Y0	III.9	Priority setting workshop RP: IT Deployment in Enterprise Sector	CNRS & ALI
09/Y0	III.10	Priority setting workshop RP: Web and Arabized Software Technologies	CNRS & ALI
09/Y0	III.11	Priority setting workshop for one research line RP: Sustainable Management Coastal Areas	CNRS & Ministries
09/Y0	III.12	Priority setting workshop for one research line RP: Integrated Water Management	CNRS & Ministries

When	Number	Action	Responsible
09/Y0	III.13	Priority setting workshop for two research lines RP: Technologies for New Agricultural Opportunities	CNRS & ARI & MoA
09/Y0	III.14	Priority setting workshop for one research line RP: Nutritional Food Quality	CNRS & MoA & MoH
11/Y0	III.15	Policy prepared and ready on inclusion of Post Doctoral, institutional support and incentives for collaboration and synergy in STIP programmes and activities	PMU and CNRS
12/Y0	III.16	All necessary preparations completed for the initiation of all eight RPs (seven mentioned above, plus the one in health and medical science) in early Y1. Arrangements made by the IA structure for RPs at CNRS. Preparations include call for tenders: • Programme document • Eligible costs • Review and grant award mechanism	RP-IA at CNRS; PMU
01-03/Y1	III.17	Start of implementation of first eight RPs	RP-IA at CNRS
01/Y1	III.18	Submission of White Book on Streamlining (Government) Procedures for research to the Interdepartmental Committee on STI	CNRS
02/Y1	III.19	Establish Joint High Level Group on New University Research Centres and Institute Policies	Universities, CNRS, MoEd
02/Y1	III.20	Establish two Joint Working Groups to prepare two new Ph.D./Postgraduate programmes	Universities
02/Y1	III.21	Establish Joint Working Group to initiate series of workshops and/or training courses for entrepreneurship and business plan development	Universities
02/Y1	III.22	Call special meeting (universities, ministries, ALI, banks, BERYTECH, etc.) to discuss way forward with respect to incubators and to result in a feasibility study along the lines preferred	CNRS

When	Number	Action	Responsible
02/Y1	III.23	Establish task force to prepare Medical Research Institute/Centre	CNRS/ PMU, after agreement with universities
02/Y1	III.24	Appoint Quartermaster to prepare Nutrition Research Centre	CNRS/PMU, AUB
03/Y1	III.25	Knowledge Gateway Industry Lebanon to start, after approval of Plan by the universities, IRI, ALI and PMU, and after appointment of Quartermaster and host organization	Host organization, PMU
03/Y1	III.26	Decision on the first (virtual) Sectoral Centre of Excellence that will be started, chosen on a competitive basis by a jury, established by PMU. Its actual founding depends on appointing a Quartermaster and a host organization	PMU, Host organization
06/Y1	III.27	Priority setting workshop RP: Mathematical Modelling	CNRS & ALI
06/Y1	III.28	Priority setting workshop RP: Renewable Energy Sources	CNRS & ALI
06/Y1	III.29	Priority setting workshop for one research line RP: Sustainable Management Coastal Areas	CNRS & Ministries
06/Y1	III.30	Priority setting workshop for two research lines RP: Integrated Water Management	CNRS & Ministries
06/Y1	III.31	Priority setting workshop for two research lines RP: Technologies for New Agricultural Opportunities	CNRS & ARI & MoA
06/Y1	III.32	Priority setting workshop for one research line RP: Nutritional Food Quality	CNRS & MoA & MoH
06/Y1	III.33	Priority setting workshop RP: Molecular and Cellular Biology to discuss the second programme in this area	CNRS & MoH

When	Number	Action	Responsible
06/Y1	III.34	Priority setting workshop RP: Clinical and Epidemiological Sciences	CNRS & MoH
07/Y1	III.35	Decision to establish Nutrition Research Centre	CNRS/PMU with the university (ies) and ministries concerned
07/Y1	III.36	Establish task force to set up teams on technical standards	CNRS/PMU with LIBNOR, IRI and universities
09/Y1	III.37	Appoint Quartermaster to prepare Virtual Centre for Instruments for Environmental Analysis	CNRS/PMU
10/Y1	III.38	Establish task force to prepare general outline of the Public and Professional Information Units	CNRS/PMU, Institutes/ Centres concerned
10/Y1	III.39	Decision to establish Medical Research Institute	CNRS
10/Y1	III.40	Calls for next ten RPs	IA-RP at CNRS, and PMU
11/Y2	III.41	Appoint Quartermaster to prepare Virtual Centre for IT facilities	CNRS/PMU

3. The Basic Sciences, Technology and Industry Sectors: Status and Recommendations

Task Force on Basic Sciences, Technology and Industry (TFI)

CONTENTS

INTRODUCTION

Prior to the civil strife (1975-1990), Lebanon was making steady progress at all levels, including the economic and education sectors. Since then, the country has suffered deeply, which has seriously hindered its development. In particular, scientific research activities have been significantly reduced. The structure of industry, one of the main driving forces behind such activities, remained confined within its traditional branches, unable to cope with the high speed of technological progress.

The absence of a dynamic research environment resulted in the lack of industrial innovation, and in the poor quality of scientific research. Most research efforts were, and still are, carried out by individual motivation without adequate institutional support. The country is witnessing an increasing number of universities and academic institutions, which are primarily oriented toward academic teaching at the undergraduate level, focusing less on scientific intellectuality, which is the driving force behind any progress in innovative scientific research.

High-technology industry exists in the country and is growing slowly in certain fields. However, this industry is still receptive in nature, but it can certainly help to turn the wheel and establish the basis for an innovative drive towards local high-technology products.

The Lebanese National Council for Scientific Research (CNRS), founded four decades ago, supports scientific research in the fields of basic and applied sciences and gives modest support to applied research in engineering and industry. However, experience has shown that the current activities of the CNRS are not sufficient to raise the country's scientific, technological and industrial achievements to a competitive standard. Following a two-year study to address the above-mentioned problems, the CNRS has realized that there is a serious need to formulate a national Science, Technology and Innovation Policy (STIP) Plan. This approach will be one of the vehicles leading to a better standard of scientific achievement.

1. Formation of the Task Force on Basic Sciences, Technology and Industry (TFI)

To formulate such a plan, the CNRS formed a Task Force for Science, Technology and Industry (TFI), whose mandate was to come up with a clear plan and recommendations to address the socio-economic needs of Lebanon, in relation to the sectors mandated to this task force.

At its first meeting, the TFI held a brainstorming discussion which led to the following proposed approach to its action:

- Identify the socio-economic needs of Lebanon
- Derive measurements of the characteristics of relevant practical steps to be taken in response to the socio-economic needs of Lebanon
- Rank these characteristics based on the measurements obtained above
- Recommend various activities (solutions) to satisfy this ranking

After several subsequent meetings and thorough discussions, the TFI adopted the following operational Plan of Action:

- Identify accepted socio-economic needs of Lebanon
- Derive adequate characteristics by proposing items that meet these needs
- Brainstorm on the correlation level matrix entries; this consists of the assignment of numeric measures between each derived characteristic and all needs
- Rank the derived characteristics based on the matrix entries
- Recommend areas of research and other activities that address these characteristics
- Brainstorm on correlation level matrix entries; this also consists of the assignment of numeric measures between each proposed activity and all characteristics
- Rank those activities based on the results obtained above

It should be noted that this Plan of Action came as a result of several meetings where its suitability was discussed at length. The decision was that this approach is an operational one and should lead to more objective results in our evaluation process. During the discussion, a distinction between manufacturing and industrialization was also highlighted.

1.1. Socio-economic Needs

During the first step of the proposed plan, the following socio-economic needs were adopted and listed as follows:

Socio-economic Needs

(1) Adopt and sustain the integrated management of energy, water and other natural resources.

(2) Lower industrial operating costs (energy, equipment and maintenance).

(3) Harness ICT and strengthen basic science research for development.

(4) Improve productivity in industry by increasing technology and information content.

(5) Shift focus to higher value, skill intensive, export-oriented industries.

(6) Establish new, suitable industries based on material sciences and technologies for development.

(7) Increase shares in international trade and export performance. Secure larger access to developed markets offering special order and fast delivery.

1.2. Characteristics of the Needs

Having adopted the above needs, the characteristics of these needs must be found. These were considered in a lengthy meeting and discussions, where the members of the Committee identified the characteristics. They consist of the elements given in the following list:

Characteristics of the Needs

- Increase national capabilities of monitoring natural resources (availability and consumption)
- Provide/identify efficient alternatives to limited natural resources
- Reduce waste in utilization of natural resources
- Introduce alternative energy-efficient production techniques
- Be able to modernize and retrofit existing flexible industrial equipment
- Be able to conduct only justified, just-in-time, maintenance operations
- Support standardization of materials and components used in production processes
- Increase real-time accessibility and management of information

- Support the continuous development and training of human resources
- Improve industrial production competitiveness through innovative and feasible basic and applied research activities
- Deliver outcomes that offer new investment opportunities
- Decrease time to market of new product
- Increase efficiency, flexibility and marketability of packaging techniques
- Support high added value, skill intensive and export-oriented industries

The relationship matrix for the suggested characteristics and needs was discussed and it was decided to use four coefficients:

- S = strong
- M = medium
- W = weak
- B = X = blank

The corresponding numerical values were initially put as follows, with the understanding that these numbers can be tuned later on if need be:

- S = 5
- M = 3
- W = 1
- B = X = 0

It was also understood that the final results of this procedure would be revised and tuned to a reasonable outcome. **Figure I** (page 140) provides the characteristics that were discussed along with the socio-economic needs. The figure also shows the evaluation of the needs-characteristics correlation matrix, which was the result of a brainstorming session.

This needs-characteristics matrix was evaluated and ranked. The results are shown in **Figure II** (page 141). These results reveal the following:

The elements of the matrix values converge toward innovative basic and applied scientific research, as well as toward ICT, human resources development and modernization. This shows the urgency of using such elements to meet and improve socio-economic needs via industrialization and intellectual activities in sciences, which today's world requires for social progress.

1.3. Solutions to the Matrix for Science, Technology and Innovation

Following the Plan, the members of the TFI proposed solutions for the characteristics whose elements could offer feasible satisfaction of societal needs. These solutions are presented in the following list:

Proposed Solution

- Establish virtual sectoral research centres of excellence (e.g. a central research and services facility for basic material sciences and chemical analysis to be coordinated with the virtual centre for instruments for environment analysis; a virtual IT centre serving the deployment of IT in industry and web and Arabized applications)
- Organize training workshops in business planning and entrepreneurship development for the scientific community
- Establish teams to support standards adaptation and adoption for Lebanon
- Carry out research programmes in renewable energy sources (e.g. chemical, wind, hydroelectric, solar)
- Establish inter-university doctoral programmes in selected fields
- Carry out research programmes in material and basic sciences, for innovative applications
- Carry out research programmes in mathematical modelling, including financial and economic applications
- Carry out research programmes in IT for manufacturing and industrial enterprises
- Initiate collaborative programmes with Lebanese scientists abroad
- Develop and maintain databases for available scientific resources (e.g. personnel, equipment, facilities)
- Establish technology promotion units, matching supply and demand
- Carry out research programmes in software, including Arabization and web applications
- Carry out research programmes in information technology

2. Evaluation and Ranking of the Solutions-Characteristics Matrix

Here, we used the same methodology as we did above for the evaluation of the other matrices (e.g. by brainstorming on the correlation levels of the matrix entries). This matrix was ranked with its numerical values and the results are given in **Figure II**. As the matrix in this figure shows, the results can be grouped into the three categories summarized in the paragraphs below.

2.1. Category I: Human Resource Development and Networking

(1) Virtual sectoral research centres of excellence.

(2) Workshops in business planning and entrepreneurship development for the scientific community.

(3) Teams to support technical standards adaptation and adoption for Lebanon.

(4) Establish inter-university Doctoral programmes in selected fields.

(5) Initiate collaborative programmes with Lebanese scientists overseas.

(6) Develop and maintain a database for available scientific resources (e.g. personnel, equipment, facilities).

(7) Establish technology promotion units, matching offer and demand.

2.2. Category II: Research Programmes for Industrial Competitiveness

(1) Renewable energy alternatives (e.g. chemical, wind, hydroelectric, solar, etc.).

(2) IT deployment in manufacturing and industrial enterprises.

(3) Mathematical modelling, especially for financial and economic applications.

2.3. Category III: Research Programmes for Innovative Applications

(1) Material and basic sciences for innovative applications.

(2) Information technology and related localization.

As can be seen, **Category I** leads to the establishment of a kind of organizational procedure to create a research environment and human dynamic process to give impetus to scientific movement and collaboration between existing and new industrial and institutional establishments (e.g. core labs, libraries, industrial

business and intellectual interactions between educational and research institutions).

In the case of **Categories II** and **III**, these are the fundamental elements and bases for research, innovations, intellectual dynamism in human resources and advances in the field of industry.

Based on the above results, we recommend the execution of such a programme by following systematic organizational procedures.

3. Strengths, Weaknesses, Opportunities, Threats Analysis (SWOT)

In the following section, we carry out a SWOT analysis for the above mentioned categories.

3.1. Category I Solutions: Human Resource Development and Networking

3.1.1 Strengths

- Large number of higher education institutions
- High quality, skilled academic staff who are graduates of internationally renowned universities
- Students committed to excellence and achievement
- Geographically close educational institutions
- Small and Medium sized Enterprises (SME) nature of industry, giving it a high degree of flexibility
- Multi-lingual scientific community

3.1.2. Weaknesses

- Lack of skilled technicians
- Lack of communication between universities and scientists
- Gap between university research activities and industrial needs
- Weak management and entrepreneurial skills of scientists

3.1.3. Opportunities

- Readiness of industry for partnership with universities
- Drive of main universities towards accreditation and rendering their activities, more attractive, relevant and internationally connected
- EuroMed Association agreement and other international cooperation programmes with Lebanon
- Need for industrial modernization and innovation through R&D

3.1.4. Threats

- Small size of local market and weak export
- Cultural obstacles due to lack of awareness of the role of the university in society
- Outdated internal regulations and by-laws of universities (e.g. promotion, merit, workload)

3.2. Category II Solutions: Research Programmes for Industrial Competitiveness

3.2.1 Strengths

- Abundant solar, wind and water resources
- Wide spread PC and Internet usage
- Available creative design skills
- Well-developed financial sector

3.2.2. Weaknesses

- Weak competitive advantages for the industry
- Lack of adequate information tools for decision making in enterprises
- High cost and wasteful management of energy

3.2.3. Opportunities

- Untapped natural resources
- Global knowledge-based economy
- Heightened awareness and commitment to environmental protection
- Deregulation and privatization of the energy sector

3.2.4. Threats

- Lack of real mapping of resources
- High real estate costs, industrial wages and communication costs
- Unstable legislative system

3.3. Category III Solutions: Research Programmes for Innovative Applications

3.3.1. Strengths

- Highly skilled, competitive, scientific workforce
- University-based and internationally qualified workforce
- Competitive, creative R&D
- Existing promising scientific sector

3.3.2. Weaknesses

- Prevailing consumerist attitude society
- Lack of R&D infrastructure system
- Insufficient commitment to R&D

3.3.3. Opportunities

- High demand for Arabic digitalized knowledge
- Demand for adequate mobile broadband
- Communications expansion
- Open worldwide market for innovative products and materials development

3.3.4. Threats

- Lack of long-term investment capital
- Accelerated emigration of educated youth
- Deteriorating living standards
- Small local market and inadequate export infrastructure system

Note: The solution matrix can be further improved if the characteristics are given weights reflecting their ranking. In other words, a characteristic ranked A should not be given the same weight a characteristic ranked H.

4. The Actors

- The Ministry of Industry
- Universities
- The National Council for Scientific Research
- The Ministry and Parliamentary Committee of Justice
- The Ministry of Education
- The Ministry of Water Resources and Electricity
- The Ministry of Environment
- Banks
- Legislative authorities
- National Employment Agency
- Professional associations

Figure I: Relationship Matrix of the Characteristics of Adequate Solutions for Socio-economic Needs

	S: Strong = 5 M: Medium = 3 W: Weak = 1 Blank = 0 SOLUTIONS CHARACTERISTICS	Improves industrial production competitiveness through innovative and feasible basic research activities	Provides e-services between sectors and government bodies	Ability to modernize and retrofit existing flexible industrial equipment	Support human resources continuous development and training	Increase real-time accessibility and management of information	Decrease time to market of new products	Ability to conduct only justified, just in time, maintenance operations	Increase efficiency, flexibility, and marketability of packaging techniques	Increase monitoring capabilities of natural resources (availability and consumption)	Introduction of alternative energy efficient production techniques	Supply efficient alternatives to limited natural resources	Support high added value, skill intensive, and export oriented industries	Deliver outcomes that offer new investment opportunities	Reduce waste in utilization of natural resources	Supports standardization of materials and components used in production processes
	SOCIO-ECONOMIC NEEDS RANKING	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	Integrate/sustain the management of energy, water, and other natural resources	W	M	X	M	M	X	X	X	S	S	S	X	X	S	X
B	Lower industrial operating cost (energy, equipment, maintenance)	S	X	S	W	M	X	S	M	M	S	M	X	X	M	X
C	Harness information and communication technologies for development	W	S	S	M	S	M	S	W	S	X	X	W	X	X	X
D	Harness and strengthen scientific research for development	S	M	M	S	W	S	M	W	X	S	M	W	S	W	X
E	Improve productivity in industry, and increase technology and information contents	S	S	S	M	S	S	S	M	M	W	W	M	W	W	M
F	Establish new suitable industries for development and job creation	M	M	M	S	X	W	X	S	W	W	M	S	S	X	X
G	Increase share in international trade and export performance. Larger access to developed markets, offering special order and fast delivery.	S	S	M	M	S	S	X	S	X	X	W	S	M	X	S
	NO. OF STRONG (S)	4	3	3	2	3	3	3	2	2	3	1	2	2	1	1
	NO. OF MEDIUM (M)	1	3	3	4	2	1	1	2	2	0	3	1	1	1	1
	NO. OF WEAK (W)	2	0	0	1	1	1	0	2	1	2	2	2	1	2	0
	WEIGHTED TOTAL	25	24	24	23	22	19	18	18	17	17	16	15	14	10	8
	PERCENTAGE RATING	71	69	69	66	63	54	51	51	49	49	46	43	40	29	23

Figure II: Relationship Matrix of Ranked Solution Characteristics

	S: Strong = 5 M: Medium = 3 W: Weak = 1 Blank = 0 SOLUTION CHARACTERISTICS	Improves industrial production competitiveness through innovative and feasible basic research activities	Ability to modernize and retrofit existing flexible industrial equipment	Provides e-services between sectors and government bodies	Support human resources continuous development and training	Increase real-time accessibility and management of information	Decrease time to market of new products	Ability to conduct only justified, just in time, maintenance operations	Increase efficiency, flexibility, and marketability of packaging techniques	Increase monitoring capabilities of natural resources (availability and consumption)	Introduction of alternative energy efficient production techniques	Supply efficient alternatives to limited natural resources	Support high added value, skill intensive, and export oriented industries	Deliver outcomes that offer new investment opportunities	Reduce waste in utilization of natural resources	Supports standardization of materials and components used in production processes	
	PROPOSED SOLUTIONS RANKING	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
H	Research programme in IT deployment in manufacturing and industrial enterprises	5	5	5	0	5	5	5	3	3	0	0	5	1	5	3	**27**
K	Establish technology promotion units: matching requests and offers	5	5	3	5	5	3	1	3	0	3	3	5	5	1	1	**27**
L	Research programme in web technologies	1	3	5	5	5	1	1	1	3	0	0	5	5	0	1	**20**
A	Virtual sectoral research centers of excellence	5	3	1	5	0	0	0	3	1	5	5	3	3	0	0	**19**
J	Creation of database for available scientific resources (e.g. personnel, equipments, facilitities)	3	0	5	5	5	0	0	0	3	1	1	3	3	0	3	**18**
G	Research programme in mathematical modeling including financial/ economical applications	3	0	0	0	5	3	5	0	3	3	3	0	3	1	0	**15**
B	Workshops for business plan and entrepreneurship development for scientific community	5	1	0	5	0	5	0	0	0	1	1	5	5	0	0	**15**
F	Research programme in material/basic sciences for innovative applications	5	0	0	0	0	0	3	3	3	3	3	1	3	3	1	**14**
C	Teams for supporting technical standard adaptation and adoption for Lebanon	1	0	3	3	3	3	0	5	0	0	0	3	3	0	5	**14**
D	Research programme in renewable energy resources (e.g chemical, wind, hydroelectric, solar)	5	0	0	0	0	0	0	0	3	5	5	1	3	5	0	**13**
E	Establish inter-university Doctoral programme in selected fields	3	0	0	5	0	0	0	0	0	3	3	3	1	0	0	**10**
I	Initiate collaborative programmes with Lebanese scientists overseas	3	0	5	5	0	0	0	0	0	0	0	1	1	0	1	**10**
	PERCENTAGE RATING	**71**	**69**	**69**	**66**	**63**	**54**	**51**	**51**	**49**	**49**	**46**	**43**	**40**	**29**	**23**	

4. The Environment and Agricultural Sectors: Status and Recommendations

Task Force on Environment and Agriculture (TFE)

CONTENTS

INTRODUCTION

The Task Force on Environment and Agriculture (TFE) – within the process of formulating a new Science, Technology and Innovation Policy for Lebanon through the National Council for Scientific Research – has been mandated to review the past policy(ies) of the CNRS in this field, evaluate the policy and propose new guidelines for a new policy for the short and medium term.

This review exercise responds to the numerous international recommendations stemming from major international activities, namely:

- First UN Conference on the Human Environment, 1972 in Stockholm
- UN Conference on environment and development, 1992 in Rio de Janeiro
- World Summit on Sustainable Development, 2002 in Johannesburg
- World Food Summit, 2002 in Rome

Additionally, the policies of the international scientific and developmental organizations, such as the United Nations Environment Programme (UNEP), International Council for Science (ICSU), International Union of Biological Sciences (IUBS) and the framework programmes of the European Union on environmental sciences have been reviewed in order to formulate the national policy. It should also be mentioned that all considerations have now been based on the societal needs of Lebanon and, to a certain extent, those of the region.

The process involved identifying societal needs, conducting a survey of the major actors, looking into the weaknesses, strengths, opportunities and threats to the sector in parallel to success stories globally prior to identifying solutions that respond to the characteristics of a successful policy and its implementation.

This exercise in foresight is expected to form the basis for future action by the CNRS. The challenge is thus to develop research lines in this sector that, "integrate environmental, social and economic pillars of sustainable development" (ICSU, 3 Dec. 2002). This report was never meant to be exhaustive, nor has it placed a priority on one or more specific need, instead it is expected to come up with a programme that could realistically be implemented within the confines of a yearly allocated budget.

SOCIETAL NEEDS

The initial discussions of the task force concentrated on reviewing the current situation in Lebanon while referring to the numerous documents available to the group.

The task force identified the following societal needs (not prioritized):

- Stabilizing coastal deterioration through sustainable management
- Integrated water management for an effective supply/demand balance
- Grasping new agricultural economic opportunities
- Improving nutritional food quality

1. Societal Need I: Stabilizing Coastal Deterioration through Sustainable Management

1.1. Justification

Approximately 50% of the coastal zone in Lebanon has been altered and most sandy beaches have been lost forever. About 70% of the Lebanese population lives along the coast (with numbers increasing during the summer months), and about 70% of the GDP is produced in this zone (ECODIT, 1996, MoE, 2001).

Lebanon has signed many Memorandums of Understanding(MoU) and protocols, mandating activities such as: the United Nations Environment Programme-Mediterranean Action Plan (UNEP/MAP), the Convention on Biodiversity, the United Nations Convention to Combat Desertification and the Protocol on Global Climate Change. Lebanon must perform and justify all the assistance it has received from outside sources.

There is perceived threat to the coastal zone due to competing interests and risk of complete loss of natural habitats and biodiversity. Furthermore, the deterioration of the quality of recreational waters might have a negative impact on human activities and on tourism in the country. Mitigating these pressures and arriving at an acceptable and stabilized situation is a priority.

There is a need for an acceptable and fair solution to the serious problem of illegal coastal development.

There is general governmental recognition of this acute problem and there has been some legislation introduced to stop dredging activities.

A better and more effective state of affairs offers potential for job creation and better mechanisms to locate sites for industry and tourist infrastructure.

1.2. Objectives

A system should be put in place to produce a comprehensive database, better knowledge and skilled personnel, together with a vehicle to convey the message to decision makers and politicians in order to gain their concerted and sustained

support for activities. This, of course, presupposes well-defined research lines and a protocol for access, retrieval and dissemination of information.

1.3. Strengths, Weaknesses, Opportunities and Threats Analysis (SWOT)

1.3.1. Strengths

- A framework exists in the Lebanese Environment and Development Observatory (LEDO) in order to pursue such activities. There are scattered monitoring activities in place
- There is an ongoing project based on three municipalities through the Ministry of Environment and UNDP in order to look into the problems of coastal area management in parts of the south of the country
- There has been some investment in the country in order to acquire capital equipment relevant to such activities
- Some legislation, such as the need for a national Environmental Investigation Agency (EIA), is already in place to safeguard the coastal zone

1.3.2. Weaknesses

- Reaction time to technical difficulties is very slow, particularly regarding peripheral matters, such as power supply, accessories, etc.
- Recycling and hands-on training for quality control personnel and equipment maintenance is needed on a periodic basis
- Legislation does not seem to be enforced universally and fairly
- There is a lack of willingness to collaborate and share information
- There is no effective STI system in place in academic institutions nor at the CNRS
- The links with industry and the private sector are, in general, weak at best
- The only institution capable of serving as a nucleus for catalyzing a concerted effort in the field is in need of staff and rehabilitation

1.3.3. Opportunities

- Opportunities for external funding are possible through international programmes and donors
- There are opportunities to improve the quality of life for the local population and for visitors/tourists
- A system in place would contribute to socio-economic development

1.3.4. Threats

- A real chance of missing out on external funding due to the absence of environmental impact assessment studies, resulting in a real danger to the well-being of the ecosystem

- Failure to attract tourists due to improper management and control practices
- Risk of being unable to cope with environmental hazards and mitigation efforts in the absence of such activities
- Lebanon not complying with the requirements of conventions and MoUs
- Impact of quick hard currency-generating tourism could stress the coastal zone, further risking the loss of more environmentally conscious tourists

1.4. Major Players for Societal Need I

The actors in the field are numerous and diverse. The major stakeholders or actors are the following:

- The ministries of: Agriculture, Energy and Water Resources, Environment, Health and the Ministry of Interior (including the municipalities)
- The National Council for Scientific Research
- The Council for Development and Reconstruction
- Academic institutions
- UN and other international agencies
- Non-governmental or community based organizations

In this regard, it should be noted that over the past eight years, eighteen international organizations and instruments have sponsored forty-six projects worth a total of US$ 30.7 million, with individual projects varying from $20,000 to $3.9 million. The actual sums are far more than the figure mentioned, as it does not show grants secured independently by NGOs, which could run into millions of dollars (MoE, 2001). Of the forty-six projects, two dealt with the question of coastal management.

The CNRS, unfortunately, has rarely been a full-fledged party to all these grants and sometimes its role has only been one of a passive observer.

1.5. Research Priorities

The task farce felt that the following are major research topics to be included in any short/medium term programme:

- Research and monitoring activities in targeted areas, as defined by other programmes, such as LEDO
- Many indicators have been defined, but no concerted action has been undertaken, nor contemplated once the outside funds have dried up

Specific Research Lines

(1) Better delineation of physical and biological systems (interaction between biotic and abiotic parameters):
- Monitoring
- Modelling
- Interactions and impacts

(2) Land use planning:
- Impact of land-based activities
- Anthropogenic effects and mitigation
- Hot spots and areas of conservation
- Coastal processes and study of geodial elevations for protection
- Socio-economic impact of coastal activities (including tourism)

(3) Introduction of new technologies in environmental studies:
- Environmental impact assessment studies
- Integrated coastal management
- GIS and remote sensing technologies
- Networking and dissemination

1.6. Capacity Building

- Inter-university programmes for graduate work in marine sciences and related fields
- Periodic exercises in quality control of laboratory workers
- Establishment of a system to disseminate technical knowledge and to make it accessible to the public
- Technical training of engineers capable of maintaining capital equipment
- Inventory of operators in public and private firms and link-ups
- Training of coastal police and rangers in protected areas

1.7. Dissemination

- A virtual museum on biodiversity and the various biotopes and ecosystems
- Guidelines for best practice for protecting beaches and coastal resources
- Website to publish current information on coastal conditions
- Informative literature for fishermen, divers, tourists and students
- NGOs and community-based structures as vehicles of communication
- Involving the written and audiovisual media as partners

1.8. Innovation

- Impact on cultural heritage through marine archaeology
- Incentives to promote tourism
- Added value to biodiversity and its possible use in bio-medical products
- Impact on community empowerment

1.9. Remarks

It should be stressed that effective implementation needs an effective coordination mechanism involving all the actors in the field. Major donors, like the UNDP, operate mainly through ministries whose scope of work does not include research, resulting in the absence of research-oriented personnel in the active inception and implementation process of programmes.

A virtual environmental core laboratory, that is properly equipped and run, will be useful for quality assurance and for all analytical problems.

The basic infrastructure in the country in the form of advanced institutions and universities exists and has an impact on human resources. However, coordination or collaboration within these institutions (be it in Ph.D. programmes or otherwise) is wanting. The importance of carrying out research (be it for a Ph.D. or Post Doctoral overseas) with access to new equipment and techniques, is obvious.

Within any new science policy, it is imperative to have a built-in system of reassessing research priorities in line with developing needs.

2. Societal Need II: Integrated Water Management for an Effective Supply/Demand Balance

2.1. Justification

While Lebanon lacks up-to-date and accurate data on water resources, there is general agreement that the gap between supply and demand will widen in the future. For example, the amount of currently available renewable water resources stands at 945 m^3 per person per year. This is expected to decrease to 833 m^3 in 2010 and further to 705 m^3 in 2025 (ESCWA, 2002b). The water deficit might further widen if degradation of some water resources continues unabated. At present, Lebanon suffers from chronic water shortages caused by supply and mismanagement problems. The water supply for drinking water and irrigation is primarily from springs and wells, surface water, hillside lakes and reservoirs. Wells, which are plentiful in certain areas, are responsible for a dramatic drop in the water table and seawater intrusion in coastal areas. Programmes in artificial recharge are few and thus fail to address the problem. Environmental measures are supported by weakly enforced regulations.

Surprisingly, surface water is at present underutilized. The government is supporting an ambitious and expensive programme of reservoir construction for the storage of several hundred million cubic meters of water. Little attention has been focused on alternative small-scale water projects which would be less costly and less likely to cause socio-economic and environmental disruptions.

Lebanon's irrigation infrastructure was damaged during the civil war and requires extensive rehabilitation in order to serve the original areas and to extend irrigation into new areas. The irrigation sub-sector is essentially unchanged since the 1970s. Nearly 80 to 90 thousand hectares are irrigated out of a potential 180,000. Irrigation is the largest user of water in the country, using more than 75% of the total, but contributing only a small fraction to the Gross National Product (GNP). Increased demands for water have sharpened the need for greater efficiency. It is a matter of national concern that, despite the high cost of rehabilitation, irrigation performance has fallen far short of expectations. Irrigation water is conveyed to the fields in open canals, most made of concrete or reinforced concrete. The most common method of irrigation is by flooding the fields. Irrigation efficiency is no more than 30 to 40%. Significant losses are mainly due to cracks in the canals, evaporation and illegal use.

Until recently, little attention was given by the water authorities to demand management measures that support improved water use efficiency. Commonly, these options include: restructuring tariffs, metering, offering fiscal incentives, issuing regulations, introducing water conservation measures and equipment for domestic use and irrigation, detecting and repairing leaks, using treated wastewater and educating users through public awareness campaigns. Even now, most of these measures are not widely used in Lebanon. The challenge is to determine which demand management measures are most appropriate and easiest to implement. The lack of a comprehensive database in the sector is one of the principal factors hindering improved water resources management in Lebanon.

Lebanese forest resources have also been systematically reduced over hundreds of years. Mountain ridges were originally covered by coniferous forest. At present, only 5 to 6% of national land is covered by degraded forest and shrubs; required percentages of forests should not be less than 20% in order to protect watersheds from soil erosion and prevent water loss.

A combination of civil strife and low government priority has seriously disrupted water resource data collection and monitoring for the past twenty-five years. Historically, rainfall records were more comprehensive than stream flow data, but in 1975 monitoring stations ceased operation. In the early 1990s, several meteorological stations were reinstated to partial operation. However, recent river

discharge measurements remain limited and ground water flow measurements are non-existent. Frequent changes in riverbed profile, high water velocities, high sediment and debris loads and other natural disturbances, limit the accuracy of existing measurements. The lack of qualified personnel and the absence of auditing and monitoring add to the uncertainty regarding the reliability of the data collected. Hydrologic and hydrometric data are often incomplete and distributed over different authorities and are not publicly accessible or even shared among the various authorities. Nor are most of the data computerized, further limiting their use for analysis.

2.2. Strengths, Weaknesses, Opportunities and Threats Analysis

2.2.1. Strengths

- There is a major project at the Ministry of Energy Water Resources for the integrated management of water resources
- There is an acceptable knowledge base, both technical and academic, to support the subject matter
- Relevant environmental codes are in place

2.2.2. Weaknesses

- Quality control is still a major concern affecting both water balance and availability
- Low achievement records and incompetence of relevant institutions are detrimental to improving sectoral services
- Lack of coordination and cooperation of conducted research

2.2.3. Opportunities

- External funding is relatively easily available for water projects from international donors
- Sectoral improvements will definitely have a positive impact on the quality of life, on the well-being of the ecosystem and on socio-economic development
- Commitments from both public and private institutions could be readily forthcoming

2.2.4. Threats

- The increasing water quality deterioration is a real threat to the community and the ecosystem
- The unpredictable weather and climatic patterns (climate change, etc.) may induce more droughts and frequent floods
- Population distribution and water supply demand imbalances are becoming more acute

2.3. Major Players for Societal Need II

Research, capacity building and dissemination of activities should be coordinated with the major actors of the water sector in Lebanon. The main actors in the water sector are hereby identified:

- Ministry of Energy and Water Resources
- Authorities of drinking water supply and sewerage
- National authority for the Litani River
- Agriculture Research Institute
- Ministries of Environment, Displaced, Agriculture, Public Health and Interior (including municipalities)
- Council for Development and Reconstruction and the Green Plan project at MoA
- Private sector (syndicate of industries and non-governmental institutions)
- UN Organizations (UNDP, ESCWA, UNICEF, UNEP, WHO, etc.)
- Lebanese National Council for Scientific Research

2.4. Objectives

The major objective of this societal need is to provide the necessary information to better understand the sector, including its resources and characteristics, and to have the necessary tools in place for decision makers.

2.5. Research Priorities

A set of research areas has been identified. For each research area, specific research activities are hereby presented.

(1) Sustaining water sources:
- Watershed management
- Assessment of ground water aquifers (local and shared)
- Seawater intrusion and salinization of soils and aquifers
- Optimizing water use (quantity and quality) in the agriculture sector and forestry

(2) Increase water availability:
- Snow water management
- Submarine fresh water sources (intervention management)
- Rain water harvesting (studies and technologies)

- Industrial wastewater effluents (innovative technologies for treatment and reuse)
- Forest management and reforestation

(3) Water conservation technologies:
- Rainfall precipitation analysis
- Reclamation and recycling of sewage (studies and technologies)
- Conservation technologies (agricultural, industrial, recreational and domestic)
- Adaptation and use of new plumbing materials

(4) Water valuing:
- Socio-economic impacts of water pricing
- Cost recovery systems
- Tariff protocols
- Privatization strategies
- Cost-sharing programmes

2.6. Capacity Building
- Graduate inter-university programmes in water resource management, water economics, policy and law
- Hands-on training and rehabilitation of technical operators in quality control
- Popularization and the making of technical information accessible to households through the municipalities and NGOs
- Better integration of the public sector with the private sector as the principle suppliers of bottled water

2.7. Dissemination
- Guidelines on best practice for water resource protection
- Informative literature for farmers and municipality workers
- Concerted efforts through the municipalities and the NGOs
- Dedicated website for people in the field on climatological parameters and weather

2.8. Innovation
- Impact on awareness and community empowerment
- Impact on traditional water conservation and irrigation practices
- Implications of global phenomena on local and regional conditions

- Impact of water valuing and pricing on conservation and on local economy
- Better construction and plumbing technologies due to saltwater intrusion
- Assist in the privatization of the water sector

2.9. Remarks

The basic infrastructure in the country in the form of advanced institutions and universities exists and has an impact on human resources. However, coordination or collaboration within these institutions (be it in Ph.D. programmes or otherwise) is needed. In any new science policy, it is imperative to have a built-in system of reassessing research priorities in line with developing needs.

3. Societal Need III: Grasping New Agricultural Economic Opportunities

3.1. Justification

Agriculture has always been an important sector in the Lebanese economy. At present, it contributes to around 12% of the national GDP and it employs an estimated 40% of the total workforce in Lebanon. The variable topography and climatic conditions, as well as the availability of water resources, provide Lebanon with good agricultural potential to produce a large variety of crops extending beyond typical Mediterranean crops to subtropical and tropical crops.

Despite this important potential, Lebanon's agricultural sector suffered tremendously in the past three decades, especially affected by the years of civil conflict. Although during the years of conflict the contribution of agriculture to the GDP rose to around 20%, this relative increase was due to a reduced contribution of the crucial tourism and services sectors to the national economy. During the two decades of civil strife, agricultural research was reduced to adaptive research and extension service was minimal, thus isolating producers and farming communities from new global scientific developments and innovations. Most notably in the areas of development of new varieties, cultural practices, integrated pest management; including processes in new concepts in sustainable rural development, with ecologically sound and economically viable biodiversity and natural resources management systems.

Accordingly, the agricultural sector that used to export fresh fruits and vegetables and several processed foods, lost its traditional markets and was no longer competitive at international markets; neither in terms of prices nor in terms of quality and variety of its produce. Though still producing vegetables, fruit trees (citrus, stone fruits, pome fruits, grapes and exotic fruits) and small fruits (e.g. strawberries), the national average yield of many fruit trees in Lebanon is often 30 to 40% lower than that of the developed countries around the Mediterranean

basin, mostly a result of the poor health status of the plant propagation material used by Lebanese farmers, poor post-harvest conditions and the absence of proper extension for pest and disease control.

Little attention was given to the agricultural sector in the past decade, since most of the public expenditure after the years of civil conflict was allocated to reconstruction and the services sector. Furthermore, the Lebanese government ratified and entered into several regional and international trade agreements, that directly affected the agricultural sector, without having a clear plan to support the sector nor to regain its competitiveness in international markets.

Despite several hindering factors related to technology, extension, economics and regulations, Lebanon can still grasp new economic opportunities in the field of agriculture if it builds on its resources with a comparative advantage over neighbouring countries. Lebanon is a small country with limited land, a high population density and a large, educated population of emigrants spread all over the world. Its local workforce is relatively well-trained, skilled and educated. Its population, including the farming communities, is known for their entrepreneurship and willingness to take risks and innovate.

Furthermore Lebanon lies within a major centre of plant origin in the world and has a long history of crop and animal domestication, dating back thousands of years. The high concentration of biodiversity, the extremely diversified topography and ecosystems and the abundant water resources, provide Lebanon with precious and unique natural resources that, if properly used, could be major assets for innovative specialized products with high value added.

3.2. Strengths, Weaknesses, Opportunities, Threats Analysis

3.2.1. Strengths

- Availability of a wide range of micro-climates and ecosystems
- Abundant water resources
- Location of Lebanon as a centre of trade between the East and West
- Availability of skilled human resources that can be instrumental in developing and implementing the needed technologies
- The Lebanese are known for their entrepreneurship and exposure to foreign market trends
- Readiness of Lebanese growers to take risks
- Presence of few projects funded by national and international bodies which can contribute to further progress in this area
- Awareness of the need for such activities

- Availability of some investment (could be limited) in acquiring equipment/ facilities required for such activities

3.2.2. Weaknesses

- Poor regulatory framework for quality control assurance (e.g. certification, quarantines, pesticide applications) and in cases where available, not enforced
- Relatively poor networking, coordination and interaction between stakeholders (including different ministries, public and private sectors and universities, etc.)
- Funding sources scattered and limited
- Small field sizes reducing the economies of scale
- Variable topography, often not allowing for effective mechanization
- High labour cost
- High cost of land and absence of land classification and zoning
- Poor extension service and technology transfer
- High costs of inputs
- Absence of market research supporting the decision making of growers (and animal producers)

3.2.3. Opportunities

- Good opportunities to attract external funding through international organizations and funding agencies
- Creation of new livelihood opportunities for the poor and improvement of the productivity of rural communities
- Good opportunities to attract investment from the Lebanese private sector, locally and abroad
- Good opportunity to enter and lead in the international market
- Development of creative innovations based on local assets that are protected by international intellectual property rights

3.2.4. Threats

- Lack of governmental commitment to long-term strategies
- Inability or unwillingness to implement regulations that are so critical for quality control
- New international agreements enforced but not considered
- Ratification of regional and international agreements leading to open markets
- High cost of living in Lebanon makes locally produced products less competitive in the region
- Countries in the region have economies of scale and cheaper labour costs for similarly produced agricultural commodities (mainly Syria and Turkey)

3.3. Specific Objectives

3.3.1. Intensive and Specialized Production of Seed/Vegetative Plant Propagation Materials (Certified Fruit Tree Seedlings, Elite Seeds, Mother Plants/ Basic Seeds of Cash Crops such as Bulb Crops and Cut Flowers,etc.)

Research

- Develop technologies which could produce, under local conditions, high quality plant propagation materials
- Develop diagnostic reagents to facilitate the assessment of the health status of the produced plant propagation materials
- Develop methodologies to free planting material from infection with different pathogens
- Market studies for the identification of most requested material with comparative advantage at the national, regional and international levels

Human Resource Development

- Training of personnel at different levels to promote research and development of all technologies required
- Training professionals in plant protection, microbiological techniques, molecular and tissue culture techniques, microbiology and horticulture
- Technical training in diagnostics, laboratory microbiological techniques, field inspection, nursery management and soil analysis

Dissemination

- It is essential to make sure that all the necessary information and technologies are available to all the active players in this activity (e.g. farmers, nurseries, large-scale seed producers, private companies). This can be established with appropriate coordination and networking
- Dissemination of information on available certified varieties and their characteristics through booklets and leaflets, as well as through observation fields and demonstration plots

3.3.2. Organic Production of Plant and Animal Food Products

Research

- Develop adaptive technologies which could be used under local conditions for the production of high quality organic products
- Develop adaptive technologies for the processing and commodity conversion of organic products
- Assess and analyze the nutritional qualities of organically produced crop and animal raw and transformed products
- Assess and develop post-harvest technologies for optimal quality and shelf life conditions of produce

- Market studies on varietal needs and best window opportunity for export of organic products to regional and international markets

Human Resource Development

- Training professionals in horticulture, plant physiology, post-harvest technology, animal husbandry animal physiology
- Train growers/producers in methods of organic production
- Train inspectors in certification procedures
- Train technicians in pesticide residue analysis

Dissemination

- Technology and information dissemination to growers/producers, processors, inspectors through demonstration plots and training centres
- Updating of inspector's guidebooks.

3.3.3. Medicinal, Agricultural and Industrial Use of Local Plant Biodiversity Research

- Breeding programmes to improve the productivity of local varieties of fruit trees, vegetables, cereals and legumes
- Studies on cultural and post-harvest technology to improve the productivity and quality of local varieties of fruit trees, vegetables, cereals and legumes
- Breeding programmes to develop new improved varieties from the wild local biodiversity: wild wheat, wild fruit, forest trees, bulb crops (onion and garlic), wild flowers for ornamental use, agricultural production, food, medicinal and pharmaceutical use
- Studies on the use of local crops for the extraction of oils and pharmaceutical products for use in the pesticide, medicinal or beauty industry (content analysis, extraction methods)
- Assessment and documentation of local traditional knowledge in the use of local biodiversity
- Assessment of local crop and animal biodiversity with regards to biotypes and population status and dynamics and the establishment of gene/seed banks as part of national ago-biodiversity programmes
- Develop new, modern, efficient and adaptive technologies for processing of local biodiversity based on indigenous methodologies and uses
- Improved nursery production of wild and local fruit crops
- Assessment and analysis of nutritional value of local varieties
- Market and consumer trend research to improve marketability and image of local products

Human Resource Development

- Prepare professionals in taxonomy, biodiversity, ecology, breeding, horticulture, plant physiology, post-harvest technology, pharmacognocy, pharmacy, animal husbandry and animal physiology
- Train growers/producers in methods of improving yields of local crops
- Train growers in identification and collection of propagative material of wild crops

Dissemination

- Technology and information dissemination for growers/producers, processors and inspectors through demonstration plots and training centres
- Distribution of newly developed varieties based on local and wild varieties to local nurseries and producers
- Publication and documentation of indigenous knowledge

3.3.4. Development and Use of Improved and Adapted Crop Varieties and Animal Breeds through Sustainable Agricultural Production Systems (i.e. Improved Use of Agricultural Inputs, Cultural Practices, Integrated Pest Management, etc.)

Research

- Assessment of the efficiency of various farming systems (both crop and animal husbandry) under the different Lebanese climatic, ecological and socio-economic conditions
- Assessment of local and new crop varieties and animal breeds for their adaptation to the different climatic zones of Lebanon and their local and regional market potential
- Evaluation of control components effective in managing major crop pests in the different cropping systems in various regions in Lebanon
- Development of sustainable integrated crop production and protection systems, minimizing the application of chemicals
- Development of sustainable integrated animal production systems with proper rangeland management systems, when needed

Human Resource Development

- Train professionals in crop physiology, breeding, protection, horticulture and post-harvest technology, agricultural economists and marketing specialists
- Train professionals in animal physiology, breeding, health, rangeland management, agricultural economists and marketing specialists

- Train personnel at different levels and the required technical critical mass to achieve this specific objective
- Train extension agents in crop and animal production

Dissemination

- Develop and assess farmers' participatory approaches to empower the farming community with knowledge to enhance and sustain appropriate technologies
- Assess the option of farmer field schools for integrated crop and pest management systems
- Internship and cooperative agreements for the training of extension agents by research centres and universities
- Seminars and information leaflets for growers and farmers
- Seminars and information dissemination through scientific publications, internet for extension agents

3.3.5. Improved Rangeland Management

Research

- Identify local pasture plants most well-adapted and suitable to the different climatological zones of the country
- Evaluate the nutritive values of such pasture for the production of small ruminants
- Identify local breeds of animals with possible cross-breeding to improve milk and/or meat production in a sustainable system
- Introduce new pasture plants with high nutritive values adapted to local rangeland areas
- Develop rangeland protection systems for sustainable production through appropriate pasture replenishment, proper grazing with adequate stocking density, rotational grazing, etc.
- Complementary research on forage production in rain-fed and irrigated land to ensure availability of roughage during winter and use of crop residues in summer

Human Resource Development

- Train professionals in taxonomy, biodiversity, ecology, plant physiology, and animal nutrition, physiology and diseases
- Train producers at different levels to achieve the objectives

Dissemination

- Information dissemination through training centres, workshops, seminars, demonstration plots and training materials (brochures, publications, etc.)

3.4. Major Players for Societal Need III

- CNRS
- Universities
- Agriculture research institutes
- Ministry of Agriculture
- Ministry of Economy and Trade
- Ministry of Industry (including LIBNOR)
- Municipalities
- Private sector: food industries, pesticide and seed companies, wholesale and retail markets, certifying bodies
- NGOs and cooperatives
- International organizations (UN and other international research and development agencies)
- Investment Development Authority of Lebanon (IDAL), Council for Development and Reconstruction (CDR) and others.

3.5. Information Technology

- Development of electronic compendia with text and images and their distribution to facilitate the task of producing high quality products
- Development of electronic support systems providing information on market needs for organic and new crops, new pest and disease outbreaks, new regulations in relevant countries, etc.
- Development of expert systems and guides for farming communities, organic producers and extension agents
- Development of growth simulation models and pest forecasting systems to facilitate the implementation of integrated crop production and protection systems that are most suitable for local farming conditions

3.6. Innovations

- Organic certification programmes, bodies and regulations to be set out and implemented
- Development of special varieties/breeds and wild crops, including organically produced ones, to add value and expand market range
- Introduction of traditional processed foods as organic products, to add value and expand market range

- Regulations on intellectual property rights of local biodiversity and local knowledge developed and implemented
- Regulations on the controlled and sustainable use of wild and endangered species and the development and implementation of rangelands in the country
- Use of wild local crops as genetic sources of resistance to various biotic and abiotic stresses in national and international breeding programmes
- Identification of effective and innovative production technologies, to encourage governmental agencies in long-term investment to improve and sustain such technologies
- Attract long-term local and regional governmental support to innovative production activities
- Improvement of productivity of rural communities and reduce the import of small ruminant meat and milk products through increasing animal produce per unit area

4. Societal Need IV: Improved Nutritional Food Quality

4.1. Justification

The purpose of improving the nutritional quality of food is to enhance the well-being of individuals, families and the population. This diverse and dynamic area integrates human nutrition, food science, food service administration, food engineering and food microbiology. It involves consumer protection, product development, food analysis, adequate labelling, basic research on diet and disease, metabolic and clinical studies.

Throughout the years, food has evolved from being a basic necessity for human survival among the general population to an essential part of a healthy lifestyle and, of primary importance to a population's well-being. Food is now defined as the safe source of nutrition that can prevent and fight modern disease. Nutrition is the science of nourishing the human body, based on the principles of dietary needs that were set by extensive research in human observation and laboratory analysis.

Lebanon is a melting pot of various nationalities and cultures, with the added impact of foreign immigrants and their habits that have been absorbed by our population and sometimes even set our local market trends. Many of our nutritional products are imported from abroad and some locally produced. Our consumers are becoming more aware of safety issues, their needs and are more inquisitive on how to satisfy their nutritional requirements. These market demands, consumer choices, market supplies and production schemes are happening in a haphazard way, without any ultimate referential body that can guide and oversee this prospering health trend.

Because nutrition is ethnic in character, problems of health, nutrition and food products are a concern. Trends in the region must be addressed through studies, surveys and observations carried out on a local and regional scale. At present, the region has a lack of reliable data in nutritional studies.

As a result, there is an increased demand for education and research in the areas of food and nutrition. Many educational institutions have recently launched educational programmes in the fields of nutrition and food science providing much potential, enthusiasm and expertise in the field. There is immeasurable growth in demand for reliable products and knowledge. However, the lack of a reliable reference body and scarcity of research are a great impediment to the generation of the necessary knowledge that will benefit local and food markets.

The quality of imported and local nutritional products requires research in effective food and nutrition monitoring systems. This would allow better regulation and control over local and imported goods, thus protecting the consumer from imitation and fraud.

The impact of local nutritional practices on health depends on research related to the association between diet and disease. The development of new products, according to specific population nutritional requirements, plays a major role in disease prevention and health bill reduction.

4.2. Strengths, Weaknesses, Opportunities, Threats Analysis

4.2.1. Strengths

- High consumer demand for nutrition education
- Available expertise in the fields of food science and nutrition
- Surging interest of educational institutions in the field of nutrition and food science
- Availability of skilled human resources in nutrient (analysis of foods)
- Availability of financial support from international organizations

4.2.2. Weaknesses

- Conflicting knowledge due to absence of a reliable reference body in food and nutrition (i.e. incubator of knowledge)
- Human and financial resources are dispersed
- Networking and coordination of activities is poor
- Producers are not in touch with recent information on nutrition
- Research is limited to individual researcher's interest
- Poor enforcement of regulations

4.2.3. Opportunities

- Proper labelling and branding of Lebanese products can enhance sales in local and foreign markets
- Production of functional foods unique to the region could promote disease prevention and treatment and provide value added products of high economic return
- Development of creative formulae based on research that can be patented
- Reduction of the health bill

4.2.4. Threats

- Faster development and registration of traditional food products by neighbouring countries
- Imitation and fraud claims that cannot be substantiated by testing
- Information not substantiated by research is being disseminated at high cost
- Limited ability of law enforcement agencies

4.3. Specific Objectives

4.3.1. Nutritional Characterization of Locally Produced Foods

This objective requires suitable development of food standards, labelling criteria and food and nutrition monitoring systems. This nutritional characterization will impart more reliability and competitiveness to our locally produced items with increased market share and export opportunities.

Research

- Determine the nutrient characteristics of Lebanese food products and label them
- Develop standards on nutritional composition of local food products and labelling criteria common to all producers
- Develop effective monitoring systems for food and nutrition quality assurance

Human Resource Development

- Train personnel at different levels to promote research and development of all technologies required to implement specific objectives
- Professionals in nutrition and nutrient standards (quality control, International Organization for Standardization (ISO) systems, Hazard Analysis Critical Control Points (HACCP))
- Professionals in food safety (food microbiology, toxicology and quality control)

Dissemination

- It is essential to ensure that all the required information and technologies are made available to all parties concerned: producers, food industry, governing bodies, consumers and nutritionists

- Dissemination of information on food regulations and standards occurs through official issuing of new policies in nutrition: newsletters, website or standard booklets
- Dissemination of information on nutritional awareness through media coverage

4.3.2. Functional Foods

Basic and applied research in the development of functional foods, according to the requirements of local communities, will make it possible to cater to the specific nutritional and culinary needs and preferences of the population, as well as to increase external market share.

Research

- Determine means of food fortification (enhance nutrient content of staple foods)
- Provide locally produced new food products to satisfy dietary needs in health and disease
- Establish relationship between food and diet-related diseases

Human Resource Development

- Nutritionists to research on dietary requirements of general and specific populations
- Food scientists (food processing engineers) to develop means of food fortification and enhancement
- Market researchers to determine market demand, acceptability and trends of new products

Dissemination

- Newsletters, newspapers, scientific journals, websites, and media coverage of specific discoveries
- Provide basic technologies to industry and private investors

4.3.3. Adequate Food Processing Techniques

Better collaboration between industry and research for the development and implementation of quality enhancing food-processing technologies should be encouraged through access to advanced industrial technologies, appropriate scientific equipment and qualified personnel and trainees.

Research

- Use of modern technology for analysis and manufacturing practices
- Development of quality enhancing food-processing technologies
- Development of effective food processing methods to preserve nutritional value of foods

Human Resource Development

- Train researchers in food technology (food processing engineers, food chemists)
- Train nutritionists and dieticians for quality control

Dissemination

- Direct line of communication between research institutions and industry for pooling of resources and exchange of expertise in various topics according to predetermined terms and conditions
- Disseminate Information provided by professional societies, NGOs and others through workshops, seminars, brochures and the media

4.4. Major Players for Societal Need IV

- CNRS
- Universities
- Agriculture research institutes
- Ministry of Agriculture
- Ministry of Health
- Ministry of Economy and Trade
- Ministry of Industry (including LIBNOR)
- Municipalities
- Private sector: food industries, pesticide and seed companies, wholesale and retail markets, certifying bodies
- NGOs and cooperatives
- International organizations (UN and other research and development institutions)
- IDAL, CDR and others

4.5. Information Technology

- Development of electronic support systems to acquire and provide information on global nutrition trends and innovations, market needs, population diseases and processing technologies
- Development of online communication help-line for all population enquiries

4.6. Innovations

- Development of a new trend of local nutritional control applied in the food industry for increased potential export markets

- Patents for new healthy food formulae, thus increasing market share of our local produce
- Innovative functional foods to enhance disease prevention and reduce hospitalization bills
- Research to develop new methods of food processing such as: preserving and/or enhancing nutritional quality of local food products, using environment-friendly technologies (energy saving, waste water, etc.) and improving economic efficiency of production techniques

4.7. Recommendations

Nutrition Research Centre

To establish a nutrition research centre that can act as a governing referential body for the local community and market.

This Centre of Excellence on which people in Lebanon and the region will rely, will use the latest technology and international standards to assess local products and provide information to the public. The Centre, therefore, will be a resource hub for the community, for Lebanon and for the region.

At present, there is detrimental misinformation among the public on diet-related disease, diabetes, hyperlipidemias, obesity and cancer. There is dire need to conduct research related to life-style practices including diets and these diseases. Public awareness should be enhanced and awareness should be created to protect the population and produce solid, reliable research.

While most countries of the West have agencies, institutions, societies and centres overseeing food and nutrition issues, this demand is not adequately fulfilled in Lebanon and many countries in the region.

Research

The Centre will address and conduct studies in a wide range of subjects, such as food analysis for nutrients, the relationship of local dietary practices and disease, the production of special foods, metabolic and clinical studies on diet – disease interaction and consumer science studies.

Human Resource Development

- Technical training in state-of-the-art technology that facilitates food analysis for nutrients
- Technical training in techniques used to study the impact of nutrients on human disease
- Education to provide professionals in food microbiology, food chemists, food engineers, and community and clinical nutritionists

Dissemination
The public needs an authority that provides information in the fields of food safety, nutrient content and eating habits for health and disease.

Information Technology Innovation
Nutrition is culture-bound. Healthy foods developed internationally are alien to the local community. It is important to enhance the nutritional quality of those locally produced foods which are known to enhance the health of the population and lower disease risk.

5. The Medical and Public Health Sectors: Status and Recommendations

Task Force on Medical Sciences and Public Health (TFM)

CONTENTS

INTRODUCTION

The state of scientific research in Lebanon needs to be evaluated regularly. This task is of even more immediate importance in the post-war years. Lebanon has been blessed with a unique geographic location that has enabled it to play an important interface role between many cultures. This resulted in a heightened awareness and involvement in education throughout its history. In recent years, the events in the region and the continuous instability have derailed Lebanon's position. Now, after healing its internal wounds, Lebanon is poised to resume a pioneering, leadership role in education in general, health and biomedical issues in particular. If the overall current status of science in Lebanon were to be critically evaluated, one could pinpoint deficiencies at many levels in our approach to science and technology. This report has been compiled to assess our Strengths, Weaknesses, Opportunities and Threats (SWOT) and it recommends strategies and modalities to address them.

GENERAL BACKGROUND

Lebanon is currently basking in the light of reconstruction after the civil war. Although the effect of the war is still widely felt, Lebanon still boasts a higher GDP than other countries in the region, a relatively young population and a high percentage of healthy, multicultural and highly educated population. Historically, Lebanon has been home not only to numerous higher education institutions, but also to some very prestigious ones. The number of educational institutions in Lebanon has recently mushroomed. This explosion in the higher educational system in Lebanon is not without perils. In the absence of significant Ph.D. programmes and uniform academic standards, interest has been focused on degrees at the B.Sc., M.Sc. and MD level, exceeding the needs of the country and therefore creating a pool of unemployed or underemployed qualified graduates. Moreover, the focus of these degrees is on the arts and humanities and theoretical sciences, with little emphasis on applied sciences. This overproduction has resulted in a mass exodus of Lebanese graduates, leading to a significant brain drain.

Excellence in education in Lebanon can be attributed to dependence on indigenous talent and a local thirst for achievement through education. This has resulted in a high percentage of educated individuals, with a relative gender unbias compared to neighbouring countries. The relative strengths of our education system are matched by some serious problems. The general disinterest in scientific research has an important impact on the quality of teaching. It is dangerous to continue university teaching without research. This situation is further complicated by the prevailing dismal economic situation and the enormous national debt, which is reflected by a meagre budget for national research.

Currently, a very small number of institutions monopolize the bulk of scientific research in Lebanon. Funding for this sporadic research effort is limited to very few sources, whether public or private. Moreover, the most productive research is usually championed by dynamic individuals based on their earlier achievements abroad, with little or no institutional incentives. The lack of reward and punishment 'up or out' in our universities, in general, cultivates a culture of apathy. This, coupled with the absence of any meaningful collaboration within the institution or between institutions, adds to the severity of the problem. The outcome is a weak research output, with few quality publications. A situation that jeopardizes the chances of receving external funding from international competitive sources or the capitalization of potential patents for important discoveries.

Research is a national priority that needs solid commitments. It is mandatory that it falls in line with the international direction. The United Nations Declaration for the Millennium Devolopment Goals asserts that scientific research is the motor for technology and advancement. The future of developing countries rests on their ability to acquire research skills. The creation of a research culture and a proper environment has not been forthcoming in Lebanon. The establishment of the tools for the creation of this proper research environment and providing all needed resources should guarantee the reversal of the current weak research output. Lebanese scientific communities should engage in a serious discussion to define research priorities, recognize the importance of scientific research and be creative in its funding. The mobilization of the private sector through tax incentives to invest in research, the creation of translational research and the linking of centres of excellence to economic players are currently missing.

1. The State of Medical and Health Science Research in Lebanon

Unfortunately, the picture of medical and health science research is not any brighter, despite a large number of physicians working in well-equipped medical centres. Although it is a developing country, Lebanon ranks amongst the statistics of other developed countries as far as the number of physicians and sophisticated medical equipment per capita. Clinical research seems to revolve around relatively unimportant epidemiological or retrospective clinical studies. This is in part due to the nature of funding, usually supported by drug companies for promotional purposes, rather than through drug development. This kind of research has a limited impact on the practice of medicine, locally and abroad.

The Lebanese population conforms to the rest of the world with respect to medical and health needs. Although there are a few regionally specific genetic and infectious diseases, the Lebanese suffer from diseases common worldwide. Some of the

specific problems arise from the developing nature of Lebanon, where ignorance and poverty may impact health issues.

1.1. Lebanon's Ambition

Lebanon has for many years established itself as a regional leader in the field of higher education, medicine and health care. Lebanon remains poised to resume this function. We believe that capitalizing on our proven history, coupled with investment in the future, should regenerate and expand our ability to lead in the fields of healthcare and medicine. It is well recognized that good quality teaching, medical and health care, depends on the upgrading of knowledge through good quality research and the production of new knowledge. Furthermore, the improvement of technology depends on the improvement of scientific research. For these reasons, investment in research will improve higher education, medical and health care. This will also create the potential for generating new companies and hence offer new jobs in the sector of biomedical industries.

1.2. Specific Aims and Recommendations

In the initial phase of STIP implementation, the task force members chose not to specify any particular research topic, but rather to recommend some general measures as well as the mechanisms for the identification of these research priorities. This choice is justified by two factors: first, our medical and health needs are common to the rest of the world. Second, current research activity must be evaluated thoroughly as a prerequisite to defining research priorities and recommending future research axes.

Four specific aims were identified. We propose the following for the improvement of medical education and healthcare in Lebanon:

1.2.1. Improvement of Higher Medical and Health Science Education through Mandating the Development of Scientific Research in the Medical and Health Fields

Good quality teaching depends on good quality research and the production of new knowledge. Most of the universities in Lebanon are institutions for the automatic transmission of 'second hand' knowledge, without any significant contribution to the production of knowledge. Scientific research is neither a hobby, a luxury nor a tool to achieve self-promotion. Research should be mandatory at the university level and research output should be used in the auditing process of universities and their teaching activities. A healthy balance between supply and demand of qualified medical doctors, basic science researchers and support personnel should be based on a continuous critical assessment of assets and liabilities, both at the local and regional levels.

Modern research does not necessarily need very expensive equipment or massive investments, which are the privilege of rich and developed countries. Today, many modern research centres could be established through relatively moderate investment provided the necessary networking and better use of available resources. Rational investment of the human potential in fields such as molecular and cellular biology requires well-defined structures rather than expensive equipment. These structures are based on qualified technicians, students and trainees (M.Sc., Ph.D., Post Doctoral), appropriate equipment, access to modern tools of information and qualified mentors with established records who could be recruited from Lebanese institutions or from abroad.

The most productive years in a student's life is during the Ph.D. and training. Lebanon so far has been deprived of the most valuable and fundamental resource, namely qualified, educated and motivated people. Therefore no effort should be spared to correct this situation. Every effort should be made to create, the necessary conditions for the successful launching of Ph.D. programmes in Lebanon. Concurrently, funding of Post Doctoral research fellowships in Lebanon should be established and encouraged. For this to be achieved, support for documented successful research by local scientists should be emphasized. This could be attained through the creation of teaching versus research tracks within universities, or the lightening of teaching and administrative duties of promising research scientists.

Local public and university funding of research proposals should be funnelled into collaborative research programmes, where the expertise of many scientists and resources are pooled to ensure the successful completion of the proposed studies. Scientific research is a highly specialized activity where the most advanced instruments and techniques are used. Furthermore, research is now evolving at a high rate that necessitates constant investment in new technologies and reagents. For this to be facilitated, the country should gear itself to deal with this issue (expedite paper work, reduce red-tape, custom and governmental restrictions, etc.). Creating the right research atmosphere should attract back to Lebanon prominent and established scientists who have proven records, as confirmed by their excellent positions outside Lebanon. Moreover, we should entice and use established Lebanese scientists from reputable institutions to contribute to the establishment and seeding of collaborative research programmes, through funding of bilateral travel and support.

Successful modern research is conditioned by recruitment of a critical mass group of researchers in one field of knowledge. This is to be considered at both national and regional levels. Otherwise, isolated researchers, even with the best qualifications, may decline over time and may fail to follow the advances of modern science. This justifies the creation of incubators and centres of excellence for a better use of available resources and as an investment to attract and enroll

newcomers. Identification through auditing and quality assurance of the research output of current and potential centres of excellence, and investing in their success through priority funding, possibly in partnership with industry, should create these incubators where applicable scientific innovations are created and their benefits are reaped.

Recommendations

(1) Legislate and audit new standards for education, training and research for existing medical and public health (health sciences) educational institutions, so as to ensure good quality teaching and value-added research conducive to certain measurable outputs. Adherence to such standards should be used for the evaluation of eligibility for re-licensure and eligibility for research funding.

(2) Identify or create centres of excellence in research to group together qualified teams of professionals, personnel and trainees with appropriate equipment, access to professional networks and modern tools of information. Senior professionals and researchers committed, partially or totally, to such centres (through incentives and reward systems from the CNRS) could serve as mentors to others. By being part of international networks of research, these centres of excellence could attract prominent and established scientists able to develop research dynamics that would develop opportunities for other researchers, thus helping to address the challenges of the brain drain.

(3) Intra or inter-university collaboration between established Lebanese scientists working in complementary fields is highly recommended and should be encouraged through incentives and reward systems, including priority funding.

(4) Increase national funding to reach a level of research competitiveness that is appropriate to attract further funding. Collect and diffuse accessible information on opportunities for extramural funding from competitive international sources. Provide technical support for the application process and improve chances through providing matching funds.

(5) Facilitate research processes at the governmental level: expedite paper work, reduce red-tape, custom and governmental restrictions.

(6) Create, over time, all the prerequisite conditions for the successful launching of Ph.D. programmes in Lebanon. Start by using a hybrid Ph.D. programme whereby foreign universities grant degrees for research activity completed in Lebanon, under the mentorship of faculty in various local universities. Also, funding of Post Doctoral research fellowships in Lebanon should be implemented.

1.2.2. Improvement of the Quality and Cost-Effectiveness of Medical and Health Care through the Development of Scientific Research in the Medical and Health Fields

Medicine is becoming a pure science rather than a pragmatic practice. Appropriate medical and health care depends on the upgrading of knowledge of medical and paramedical staff. We should aim to put restrictions on the current abuse of medications, medical procedures and sick-leaves, which represent a substantial economic drain. Appropriate and responsible engagement of the health care system by beneficiaries and consumers would result in serious economic savings through: (i) avoiding illness, disease and sickness, (ii) rational use of physical facilities, technology and pharmaceuticals, (iii) responsible attitudes towards sick leaves, and (iv) proactivity in favour of prevention and promotion activities.

The improvement of the quality of health care in a country depends on the concepts of continuous medical education, auditing and quality control. Continuous medical education depends intimately on continuous production of knowledge through research. The development of research-dependent medical centres of excellence that will attract regional interest should be established.

Quality control and auditing must be based on updated knowledge of procedures and advances in knowledge. Quality care depends on the adequate training of medical students, interns, residents, fellows and paramedical personnel. This training depends on the educational institutions' contribution to knowledge and the ability to acquire new and appropriate technologies.

Recommendations

(1) Encourage and provide incentives for the creation and development of multidisciplinary research teams that integrate basic health and medical sciences with social sciences and clinical medicine.

(2) Encourage and provide incentives for the involvement of social scientists in health-related research.

(3) Encourage and provide incentives for research in the fields of health promotion, prevention, rehabilitation and mechanisms towards the identification of alternatives to hospitalization.

(4) Develop research-involved health and medical centres of excellence which can attract national and regional attention and interest.

(5) Encourage and provide opportunities and incentives for the involvement of paramedical personnel in modern medical and paramedical technologies.

1.2.3. Creation of Academic/Industrial/Community Bridges for their Mutual Benefit through Biomedical Technology Transfer and Development

The United Nations Declaration for the Millennium Development Goals asserts that scientific research is the motor for technology and advancement. Improvement of technology depends on improvement in scientific research. The financial resources available to researchers can be divided into four categories: (i) government sponsored research, (ii) academic institutions' sponsored research, which also serves as a conduit for charitable funding, (iii) drug and pharmaceutical manufacturing companies and (iv) lastly, extramural competitive international funding.

A valuable source that should be tapped into and developed upon, based on other countries into successful experiences, is partnerships with local and international biomedical industries. Biomedical technologies include pharmaceuticals, biotechnology, medical devices, hybrid devices, biomedical engineering, diagnostics and health care-related information technologies. In the area of biotechnology, there is a long lag phase between initial investment and profitability, thus it is difficult for capital markets to assess accurately the risks associated with early-stage technologies. For these reasons, and due to the lack of incentives to encourage such investments, the private sector does not commit funds to commercializing the results of basic and early-stage applied research. Currently, in Lebanon, support for basic and clinical research from industry is negligible. Special effort should be made to provide clear and attractive information in exchange for investment opportunities in medical research and technologies.

To convince local industrialists using imported technology to invest in local research and biotechnology, several mechanisms should be implemented. This could be initiated by giving tax incentives to get the 'ball rolling'; thus the process could serve as a starting point for confidence building.

Such a process should be accompanied by establishing bridges between researchers looking for sponsors and industrialists looking for investment. The CNRS needs to initiate such interaction by providing proof-of-concept funding through seed capital, to be followed by an early market development fund.

Recommendations

(1) Investigate selected sectors where we can carry out contract research for international industry with limited funds. A relevant example is through the establishment and funding of new research programmes in genomics (proteomics, structural genomics, drug discovery, pharmacogenomics, etc.) where investment is likely to be profitable in the short and long-term.

(2) Mobilize interested community and industry representatives as well as activists in research boards/steering committees and in research-related decision making entities.

(3) Allocate higher priority and proactive funding for research programmes/activities that aim to produce a product that is of value to the targeted industry of concern, and that could be marketed in actual or adapted form.

(4) Sponsor advanced training (Doctoral and Post Doctoral) in fields that would facilitate value-added product-oriented research.

(5) Encourage the private sector to invest through tax incentives.

(6) Promote, through the appropriate means, potential investment opportunities made available through value added product-oriented research.

(7) Mobilize dedicated professional, financial and legal resources to support value added product-oriented research. Such resources would be important for patenting, marketing, financing, etc.

1.2.4. Establishment of an Adequate Environment to Host and Develop Qualified and Creative Minds in the Fields of Medical, Biomedical and Health Sciences

Qualified researchers are forced to leave Lebanon to find proper opportunities abroad (brain drain). Furthermore, young researchers coming back to Lebanon or recruited by many local institutions cannot find the proper environment that provides an adequate infrastructure and opportunities to continue their research activities.

In an attempt to break this vicious cycle, it is essential to establish research centres with the entire necessary infrastructure (equipment and qualified personnel) that can provide opportunities to host young researchers – Ph.D. students and Post Doctoral fellows – and can promote collaborative efforts between researchers at national and regional levels. This should be achieved through the establishment of physically independent research centres managed by the CNRS, as one alternative.

One such centre should contain all the necessary equipment for molecular and cellular biology, as a basic tool for modern research in these pioneering fields, as well as other facilities that correspond to the set priorities for other medical research. This centre must also contain a basic skeleton (critical mass) of qualified

technicians and research assistants and must be managed by one or two senior scientists with established and recent achievements in one field of medical and health science.

The Centre can also carry out research by creating contracts with other institutions or companies in Lebanon or abroad. These contracts may provide a source of revenue to the Centre.

Finally, the scientific activities of this centre should be audited on an annual basis by an international panel of specialists.

Recommendations

(1) Establish an autonomous research centre, preferably managed by the CNRS. This Centre should be associated with different research centres and universities in Lebanon. Its ultimate goal is to provide the proper mechanism and to help transfer research and research culture to Lebanese universities.

(2) The Centre should contain all the necessary equipment for molecular and cellular biology, as well as other facilities that correspond to other research areas in the medical and health fields.

(3) It should group a basic skeleton of qualified scientists with full-time research positions (full-time researchers) and qualified research assistants or technicians. Several group leaders are required to maintain sustainable, productive and high quality research activities. Research programmes will benefit from the expertise and the involvement of visiting Lebanese scientists working within institutions in Lebanon or abroad.

(4) The Centre should be led and managed by one or two senior scientists with established expertise and achievements in the fields of health and medical sciences.

(5) This Centre would host and provide services to Ph.D. students, Post Doctoral research fellows, junior and senior researchers and university professors.

(6) This Centre would create academic/industrial/community bridges and may/should lead to the creation of a technopole for biomedical and health-related technologies.

(7) The scientific activities of this research institute should be audited on an annual basis by an international panel of specialists.

2. Mechanisms for the Implementation of the STIP Recommendations

This report addressed the central specific aims in a research policy for the health and medical field and the appropriate individual or overlapping recommendations for their implementation. In medicine, research is of an applied nature, whether for short or long-term considerations. Furthermore, some research issues in the health and medical fields could become a priority, depending on the prevailing circumstances.

Considering the highly competitive international research activities in various biological domains, and the very limited resources in Lebanon, a prudent policy must concentrate on the establishment of multidisciplinary research groups or units that attract specialists and experts from different disciplines (molecular, cellular and system biology, bioinformatics and biotechnologists among others). These qualified groups, due to their flexibility, would be able to tackle different research topics (cardiovascular, cancer, aging, genetic, infectious diseases, etc.) with minimal requirement for extra equipment and human resources.

In addition to the previously formulated recommendations regarding each specific aim, it would be most useful if the future direction of research in Lebanon was based on, and related to, what has been done in the health research field in the last five years.

It is fair to assume that our current research strengths and activities in Lebanon will be, at least for the coming years, maintained at the same level and potentially increased. The following criteria would be used to develop a national consensus on research priorities in Lebanon:

(1) Analysis of research activities and research output in Lebanon in the last five years:

- Quantitative analysis and tabulation of the distribution of funded research proposals submitted to the CNRS, based on the assumption that research applications to the CNRS constitute a representative sample of research in Lebanon
- Quantitative and qualitative analysis of the research output (list of publications in peer reviewed international journals)
- Identification of the sources of research funding, as well as the institutions that have received research funding in the past. (Amount of extramural and total funding), when available

(2) It is also important to identify what human resources and infrastructure facilities exist in Lebanon. This mapping will include an estimate of:

- The number of established researchers
- The number of recent recruits in the biomedical research fields
- Major equipment and its distribution
- The number of qualified engineers, technicians and other personnel
- The number of trainees (MS, Ph.D, Post Doctoral) and their distribution in various institutions.

The data generated through the analysis of research activities its output and the mapping of human resources and infrastructure facilities, shall serve as a basis to be used by a committee of international experts, to define the three or four major research areas that should be the focus of Lebanese researchers in the health fields in the next five to ten years.

The recommendations of the committee of international experts should lead to:

- The definition of the basic structure of the Lebanese National Centre for Health that may house the basic core of full-time researchers and technical staff and conduct some research on some of the proposed projects
- The formation of the major research groups based on existing research activities in various institutions

3. Strengths, Weaknesses, Opportunities and Threats Analysis

3.1. Major Players

- Universities and affiliated teaching hospitals
- Local funding agencies: the CNRS and other governmental agencies, NGOs, UN agencies (WHO), other donors
- International funding agencies: EU, NIH, NSF, French CNRS and INSERM
- Drug companies, local pharmaceutical industry
- Third party payers: MoH, NSF, insurance companies

- Human resources: scientists and faculty professors, students (local, foreign), physicians, engineers, biostatisticians, computer specialists, qualified technicians, educators, administrators, patients

3.2. Strengths

- Numerous higher education institutions, some using research output as criteria for promotion
- Excellence dependent on indigenous talent
- Relatively young population with tremendous eagerness and understanding of the value of higher education
- Healthy sector of multicultural and highly educated population
- Large highly educated Lebanese Diaspora
- Pioneering role for graduates from Lebanese universities in regional development
- GDP relatively higher than in other countries in the region
- Statistics in Lebanon rank similar to other developed countries as far as the number of physicians and amount of sophisticated medical equipment per capita
- Public awareness of the importance of scientific research
- Lebanon was a pioneer in investing in scientific research in the Middle East (the CNRS was one of the first in the region)
- Adequate environment for the development of individual initiatives

3.3. Weaknesses

- Most universities in Lebanon are institutions for the automatic transmission of 'second hand' knowledge without any significant contribution to the production of knowledge
- Emphasis on the arts and humanities and theoretical sciences, with little emphasis on applied sciences
- Absence of significant Ph.D. programmes
- General apathy for scientific research within universities, which has a significant negative impact on the quality of teaching
- Meagre national budget for research due to the prevalent economic situation
- Unbalanced distribution of research activities and facilities
- Few or no institutional incentives: lack of reward and punishment, 'up or out'
- Weak research output with few quality publications

- Most productive research championed by dynamic individuals based on their earlier achievements abroad
- Limited capitalization on potential patents from important discoveries
- Clinical research seems to revolve around relatively unimportant epidemiological or retrospective clinical studies, with funding usually supported by drug companies for promotional purposes rather than through drug development
- Lack of collaboration between different researchers or groups working on related topics
- Support for basic and clinical research from industry is negligible, due to lack of incentives to encourage such investments, lack of confidence of pharmaceutical companies in research ability in Lebanon, lack of confidence of Lebanese scientists in local industry

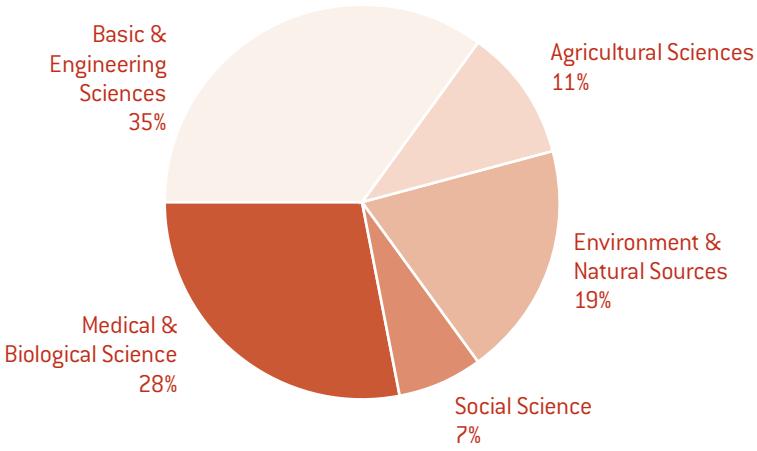
3.4. Opportunities

- Low cost of quality research compared to Europe or USA
- Potential support from Lebanese Diaspora and established networks in different countries
- Large number of qualified people in various areas
- Openness of Lebanese society to various cultures, which is unique in the Middle East
- Free expression environment
- International funding through recent partnership agreements, (e.g. with the European Union and international support to Lebanon through Paris II Conference and others)

3.5. Threats

- Increased competition caused by European partnership agreements when the grace period is over
- Increasing regional competition including countries in the Far East
- Mass exodus of graduating students leading to a significant brain drain
- Isolated researchers, even with the best qualifications, decline with time and fail to follow the advances of modern science
- Negative impact on the future of the young population from the overwhelming presence of inflated higher education institutions
- Limited availability of funds for scientific research due to the economic situation

CNRS Projects by Discipline (2002-2007)



Source: CNRS, updated October 2008

6. The Socio-economic Needs in Lebanon: Analysis and Assessed Impact of STIP

Task Force on on Socio-economic Analysis (TFSE)

CONTENTS

INTRODUCTION

The world economy is undergoing a dramatic transformation as countries move to an economy driven by high technology industries and the application of new technology in traditional industries. To compete in this new economy, states must have an economic base of firms that constantly innovate and maximize the use of technology in the workplace. Also critical is a strong Research and Development (R&D) base that can provide these technology-intensive companies with access to state-of-the art research, researchers and research facilities.

Elements of a Lebanese Technology-based Economy
A technology-based economy requires:

- A strong intellectual infrastructure, such as universities and public or private research laboratories that generate new knowledge and discoveries. Lebanon could have a comparative advantage in this respect;
- Efficient mechanisms through which knowledge is transferred from one person to another or from one company or institution to another;
- Excellent physical infrastructure, including high-quality telecommunication systems and affordable, high-speed Internet connections;
- A highly skilled technical workforce;
- Good sources of capital.

Each element has a direct impact on the Lebanese R&D base and, therefore, on its ability to support a technology-based economy. Many countries are building their R&D base through initiatives that address these elements.

1. Major Lebanese Socio-Economic Issues

The base of socio-economic statistical information in Lebanon needs new efforts to be comprehensive, updated, coherent and sustainable. This informational base was seriously eroded in Lebanon during the civil strife (1978-1991). The Central Administration for Statistics (CAS), which was reactivated in 1993, has since then, been actively trying to create this base. The CNRS could take the initiative to create such a base for S&T indicators and for Knowledge-Based Economy (KBE) indicators in general.

Due to the lack of consistent and coherent indicators, we were obliged to get such information from different sources, mentioned in the references at the end of this chapter, including the Ministry of Industry (MoI), Ministry of Education (MoEd), Ministry of Environment (MoE), UN Economic and Social Commission for Western

Asia (ESCWA), United Nations Development Programme (UNDP) and the Economist Intelligence Unit (EIU).

The table in **Annex I** (see page 215) shows key indicators for the socio-economic status of Lebanon from 2000-2002. Major points of concern are: the high unemployment rate, high debt, negative industrial and manufacturing growth rates, negative national saving rate, high budget deficit, high deficit in balance of trade and low Foreign Direct Investment (FDI). For all these issues, STI play a very important role, especially with the trend towards the KBE.

On the other hand, Lebanon has many points of strength, opportunities and comparative advantages. Lebanon has one of the highest literacy rates in the region, with advanced human resources and human capital. It enjoys a free open market economy. The banking system used to be one of the richest in the region, able to finance important local development initiatives and programmes. The tourism sector used to be one of the most important in the region. Lebanon is the gateway between the Middle East and the West with an important cultural legacy, as well as historical, archaeological sites and natural recreation sites. Lebanon used to be, and could be again, an attractive centre for higher education in the region, with high ranking universities and colleges. Medical and health services could also become an important economic sector. Agro-industry has potential for improvement. Finally, great potential and opportunity would be to revitalize the existing industrial sector and to create new KBE. In all these opportunities and needs, R&D could play a major role.

In the following subsections, a summary of the major socio-economic issues and needs will be surveyed. This will include the population and education, general economic performance, the industrial, agricultural, health and medical sector, national resources, tourism and the financial sector.

1.1. Population and Education

Lebanon enjoys a steady population growth; the actual population is estimated to be around four million inhabitants. The percentage of youth in this population is high. The population under twenty represented about 39% of the total in 1997, while the population under forty represented 73%. This high percentage of young people could be a positive factor for economic growth, since this population is well educated and represents an important human capital. The illiteracy rate is low for this young population for both males and females (**see Table 1**).

A major issue is the brain drain in Lebanon whether it be individuals emigrating from remote governorates to large cities or from Lebanon to foreign countries like: Australia, Canada, Europe and the Arab Gulf. A major socio-economic need is the creation of high added value production and services sectors to offer attractive jobs in all Lebanese Governorates. KBE and services are the most appropriate for responding to this socio-economic need.

Table 1: Literacy Rate by Age Group and Gender, 1996 (%)

Years	Male	Female
10-14	2.0	2.2
15-19	3.6	3.6
20-24	4.1	4.8
25-29	4.6	7.0
30-34	5.5	8.5
35-39	5.8	11.5
40-44	6.9	16.8
45+	22.1	46.0

Source: UNDP
Ref: EIU, CP-2002, Lebanon

1.2. General Economic Performance

Lebanon has an economically open, service-based economy. Annex 1 shows major economic indicators. **Table 2** below compares selected indicators between Lebanon, Jordan, Syria and Egypt. Lebanon's GDP/capita is the highest of the non oil-producing Arab countries. The current account-balance, as a percentage of GDP, is highly negative. External debt/capita is very high. Export and import levels are highly imbalanced (see **Figure 1** on page 193). This trade imbalance is estimated to be around US$ 5 billion.

Table 2: Comparative Economic Indicators, 2001

Economic Indicators	Lebanon	Jordan	Syria	Egypt
GDP (US$ billion)	16.5	9.0	19.8	84.8
GDP per head (US$)	4,635	1.730	1,154	1,299
GDP per head (US$ at PPP)	7,539	3,957	3,424	3,468
Consumer price inflation (av; %)	0.5	1.8	0.4	2.3
Current-account balance (US$ bn) % of GDP	-4.1 -25.0	0.1 0.6	0.2 1.1	-0.1 -0.1
Exports of good free on board (f.o.b.) (US$ billion)	0.9	2.3	5.0	7.0
Imports of good f.o.b. (US$ billion)	-6.7	-4.3	-4.2	-15.8
External debt (US$ billion)	15.2	8.2	22.3	28.6
Debt-service ratio, paid (%)	35.5	12.2	6.4	10.5

Source: Economist Intelligence Unit, CountryData
Ref: EIU, CP-2002, Lebanon

The distribution of GDP by sector is shown in **Table 3** below. The industry share, including water and energy, is estimated to be around 17.5 % of GDP, agriculture 12.6%, construction 9.4% and commerce 13.5%. These estimates go back to 1995. On the other hand, the share of industry and manufacturing as a percentage of GDP, between 1990 and 2000, has, on average, been declining (see key indicator given in Annex I).

Table 3: GDP by Sector, 1995* (% of total)

Commerce	30.5
Water, energy & industry	17.5
Other services	16.6
Agriculture	12.6
Construction	9.4
Public administration	7.5
Housing	4.2
Transport & communication	2.9
GDP	**100.0**

***A one-off survey, which has not been repeated, but it is believed the composition has changed little since 1995.**
Source: Central Administration for Statistics
Ref: EIU, CP-2002, Lebanon

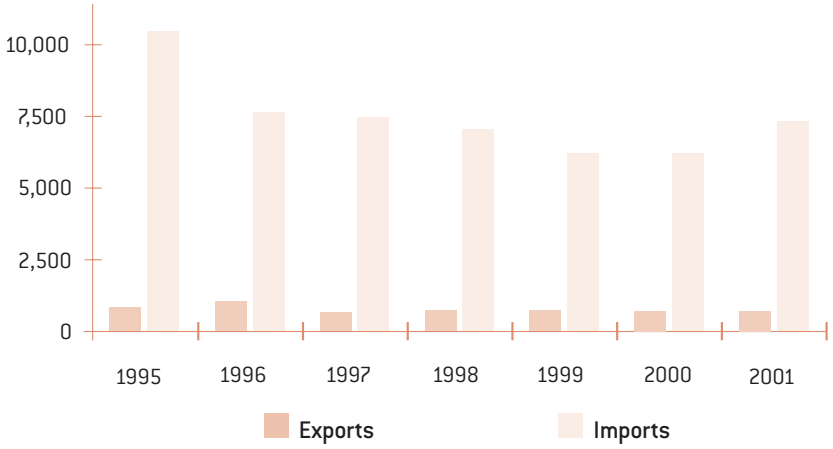
1.2.1. Gross Domestic Product (GDP)

Real GDP growth was estimated to be 1.5% in 2002, and expected to accelerate. The modest upturn reflects the positive impact of the Paris II Accord on domestic and foreign confidence. The disbursement of project-specific funding for capital projects under Paris II was expected also to boost capital spending. The economic upturn is expected to gain momentum during the coming years, although higher import volumes will limit the overall pace of expansion to around 2.5%.

1.2.2. The External Sector

Lebanon's overwhelming dependence on imported goods will ensure that trade and current-account deficits remain high during the forecast period. The complete absence of data on non-goods transactions makes projections of the current account highly unreliable. However, we forecast some further strengthening of service and income credits and a slowdown in income debits growth (as a result of Lebanon's new access to concessional foreign debt).

Figure 1: Export and Import Levels (US$ millions)



Ref.: WB-CUS (17/9/2001)

1.3. Current Situation of the Industrial Sector

The Industrial Sector (IS) has been evolving in Lebanon since the fifties. It represents about 13% of GDP in recent years. There were around 22,000 units in 1998. Half of these units exist in Mount Lebanon, 12% in Beirut, while the rest, which account for only 36%, are distributed all over the rest of Lebanon.

It is clear that the concentration of the workforce is in Mount Lebanon and Beirut, representing 66% of the total number of workers. Unlike many states in the region, Lebanon never passed through a period when the government sought to create large nationalized industrial firms. Instead, it has historically relied on import for the majority of industrial and consumer goods. The IS, as seen from the mentioned references, is composed almost entirely of small family-owned firms employing less than ten people, converting semi-finished imported goods for the local market, or producing bulk items such as furniture, paper products and beverages. Value added industries are confined to a small jewellery-finishing sector and an equally limited fashion industry. There is also a small market for time-sensitive and delicate goods, such as unprocessed food. As a result, most Lebanese manufacturers are located around population centres to reduce transport costs.

Serious efforts have been exerted in the last few years to develop IS in Lebanon. The private sector, the Association of Lebanese Industrialists (ALI) and the Ministry of Industry (MoI) have been deploying these efforts. One of the main objectives has been to increase industrial exports and reduce imports.

In 1998, sales totalled US$3.72 billion, where the value added amounted to $1.82 billion, corresponding to 49% of the sector's sales ($80,000/firm, $12,500/labour), as shown in a survey by MoI.

In addition, the survey showed that 69.9% of the 22,107 firms employ less than five workers (per hour workers); while firms employing more than ten employees represent only 9.5%. However, those employ around 42.5% of total employees and generate 61.4% of sales.

If we categorize the IS, we will find that 20.2% of production goes to the food and beverage industry, 16.3% to furniture, 13.9% to metal products, 13.6% to clothing and 6.6% to wood products. Yet, these products represent only 71% of the total industrial sector. The remaining 29% are concentrated on other manufacturing products, but employ 40.4% of the labour force of the IS and generate 48% of total industrial output, as shown by the survey.

The main results of the survey were summarized as follows:

- Small size of the industrial firms
- Labour intensive production/investment
- Salaries represent a big share of the total expenditure
- Limited diversity in production
- Family business predominance, with monopolized decision-making

The IS in Lebanon faces general problems and challenges, which are:

Internally

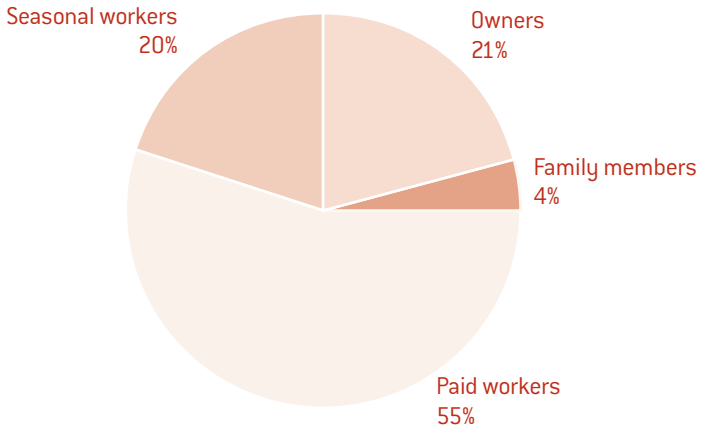
- Recession
- Limited industrial investment
- High costs of production (raw material, power, etc.)
- Low quality of products making them more difficult to penetrate foreign markets
- High transaction costs, leading to increase in opportunity cost (time, money)
- Lack of resources at the MoI which is essential for proper management of the sector

Externally

- Strong international market competition (absence of quality, conformity and standards)

- High competition in the Foreign Direct Investment (FDI) market (due to lack of appropriate environment to attract FDI
- Increase in regulations, resolutions and standards codes after signing trade agreements with Arab countries and the WTO (ensure required standards)

Figure 3: Labour in the Industrial Sector, Survey of the Ministry of Industry, 2003



Source: MoI Lebanon, 2003

Steps to enhance industrial development proposed by MoI and the ALI would consist of general measures such as:

- Improvement of the industrial information and technical consulting services
- Creation of legal and organizational frameworks triggering incentives for industrial development
- Improvement of the industrial infrastructure
- Reduction of the production cost
- Provision of sources of finance with attractive conditions
- Modernization of the sector
- Expansion of local markets for local commodities and the fight against dumping
- Development of exports
- Organization and administration of WTO negotiations from a strategic perspective

Examples in a survey undertaken concerning the growth and decline of various manufactured products show that there is potential for the Lebanese IS to be developed. It shows also that high and medium technology industries have a better chance for such development. There is a huge need and potential for the development of the IS. The MoI has argued that the output of the IS should be of the order of US$8 billion, instead of about $3 billion now.

Revitalizing the IS is a major socio-economic need. Establishing a more favourable environment for this sector is a vital measure to be taken. Promoting S&T, fostering innovation, building an absorptive capacity for technology transfer, improving total quality management, expanding information technology infrastructure (particularly industrial information) and establishing S&T parks and incubators are all essential measures to be taken by the public and private sectors in Lebanon.

The public and private sectors are still adopting the concept of industrial zones. These zones are based on assembly under license or import-substitute manufacturing. Whereas, what is needed is technology parks, technology incubators and centres of excellence where R&D and innovation are the primary activities.

1.4. Current Situation of the Agricultural Sector

The agricultural sector represents about 12.6% of GDP (see **Table 3**, page 192). Lebanon enjoys plentiful sunshine, a good water supply and fertile soil. The Lebanese agricultural sector has the potential to be one of the most productive in the region. Instead, it is underdeveloped and poorly managed. Most holdings are small and use outdated, inefficient production and irrigation technologies. Most farmers are poorly educated and are not well advised in choosing their crops, for example, growing low-yielding staples such as potatoes which can be sold and consumed locally, rather than more lucrative cash crops for export. Output is also often of questionable quality.

According to ESCWA, Lebanon has some 207,060 ha of arable land, with 60,047 ha of that irrigated. Another 360,000 ha are suitable only for grazing, while 79,560 ha comprise forests and woodland. The most important agricultural areas are on the high Beqaa Valley, which accounts for 35% of farmable land, and the fertile coastal plain, accounting for a similar area. The Beqaa is mostly sown with root vegetables, some cereals and tobacco, which together account for about 30% of total production. Coastal areas generally grow fruits, such as citrus fruits, bananas, melons and apples. The government subsidizes the production of some crops, such as tobacco, to provide indirect support for rural populations in the south and in the Beqaa.

Most output is consumed locally, although some is exported, primarily to the USA and Saudi Arabia. Limited funding, receiving just 0.33% of the state budget in 2002, or US$22 million, also curtails the sector. Private-sector finances are equally limited, with bank loans to agriculture accounting for only 2% of bank credits. The net result has been a shortage of investment and old technologies undermining productivity and competitiveness. In international markets, Lebanese agricultural goods trade alongside output from the EU and other countries in the region, which is often sold below cost-price because of production subsidies. Unable to match subsidies offered elsewhere, successive governments have chosen to protect the industry by restricting food imports.

Table 4 shows land use in Lebanon. About 50% of the land is arable and forest, which is a large percentage compared to other countries in the region; cultivated land is owned by the private sector.

Table 4: Area Cultivated by Major Crop Type (Dunum)

CropType	1980-1995*	1999**	Percent Change
Cereals	1,020,000 (1989)	518,420	- 49%
Fruit trees	560,000 (1989)	595,147	+ 6%
Olives	350,000	524,213	+ 50%
Industrial crops	n/a	247,265	n/a
Vegetables	230,000 (1988)	452,320	+ 97%
Other	n/a	142,000	n/a
Total	**2,850,000 (1980)**	**2,479,365**	**- 13%**
	2,740,000 (1986)		**- 9.5%**

** Source: METP/ERM, 1995 (reported values cover different years)*
*** Source: MoA/FAO, 2000*
Ref.: L.S.O.E.R., 2001

The area cultivated by major crop types and its evolution between the 1980s and 1990s is also shown in **Table 4**. A net increase in the area cultivated with vegetables and olives is clear, while an important decrease in the area cultivated with cereals is also noticeable.

On the other hand, the evolution of livestock production between 1980 and 1999, given in **Table 5** (page 198), indicates a percentage increase of 160% of sheep and 36% of cows.

The productivity of the land and the workforce is not high; R&D in the agricultural domain and in biotechnology, to increase this productivity and to promote agricultural export, is an essential economic need in Lebanon. Agro-industry could play an important role in the Lebanese economy, provided new technologies are introduced for higher quality and higher productivity and competitiveness. Livestock production is gaining steps, and is a potential sector, if new technologies are absorbed to promote its productivity.

Table 5: Evolution of Livestock Production (1980, 1999)

Category	1980	1999	Variation (%)
Cows	55,612	75,874	+ 36
Sheep	145,068	378,050	+ 160
Goats	444,448	435,965	- 2
Total	**645,128**	**889,889**	**+ 38**

Source: MoA/FAO, 2000
Ref.: L.S.O.E.R., 2001

1.5. Current Situation of the Health and Medical Sector

The healthcare system in Lebanon is well developed with high-quality care available, though it is expensive. For those born from 1995 to 2000, the average life expectancy is one of the highest in the region, at 72.6 years, compared with 61 in Egypt. Infant mortality is relatively low at around 28 per 1,000 live births, which is much lower than the Middle East average of 51. In 2000, there was one doctor for every 476 people in Lebanon, compared to 1,320 people in Egypt. **Table 6** shows certain healthcare indicators that are relatively high compared to most of the countries in the region.

Before the civil strife, medical services used to represent an important economic sector at the regional level. It is now only a potential sector.

Medical R&D enjoys the highest R&D field expenditure compared to others in Lebanon. If this R&D is market-oriented, it would promote the growth of this sector.

The pharmaceutical industry is another potential subsector. An evaluation of this subsector and its market, nationally and regionally, could help to direct R&D in this field. Biotechnological research is a promising source of innovation. Lebanon could specialize in selected activities in this field, which is market-oriented.

Table 6: Healthcare Indicators, 2001

Life expectancy at birth (years), 1995-2000	72.6
Infant mortality rate (per 1,000 births)	28
% of population with access to : Health services Safe water Sanitation	 95% 100% 99%
One-year-olds	88.0
% population over 15 years old who smoke, 1997	53.6%
Health expenditure, public (as % of GDP)	2.2%
Health expenditure per capita (US$), 1998	$469
Births attended by skilled health staff (%)	88.0%
Physicians (per 100,000 people), 1990-99	210
Daily calorie intake per head, 1996	3,319 Kcal

Sources: UNDP, Ministry of health Ref: EIU, CP-2002, Lebanon

Medical tourism is another economic activity that Lebanon could venture into. The Malaysian experience in this field is rich and should be examined.

1.6. Current Situation of the Natural Resources Sector

1.6.1. Energy

Lebanon imports all of its fuel. Primary energy consumption has been steadily increasing over past years. It was about 4,129 Ktonnes in 1995 and increased to about 4,963 Ktonnes in 1999, equivalent to an increase of 18.5 %. Currently, the petroleum and gas sector is the responsibility of the Ministry of Energy and Water Resources (MoEW). The government bill for petroleum products was about US$805 million in 1999. Power generation from hydroelectric plants has fluctuated in recent years, peaking in 1998 at 786 KWh and then declining to 331 KWh in 1999. The total power generation (hydroelectric and thermal) was 8,356 in 1998 and 8186 KWh in 1999.

The use of solar energy to heat water continues to be very limited in Lebanon, compared to neighbouring countries such as Cyprus, Greece and Jordan. According to one study (*Le Solaire au Liban*, ALMEE, 2000), the installation of 400,000 solar heaters in Lebanon over a ten-year period, would entail an electricity energy saving of about 8%; and consequently avoid the need to expand power production capacity by 100MW, thus saving more than $100 million yearly as capital cost. On the other hand, it would lower the energy bill by about $30 million over ten years and would also reduce the atmospheric pollution from thermal power plants.

R&D on renewable energy and on energy conservation is an essential need for the Lebanese economy. The establishment of the Lebanese Centre for Energy Conservation and Planning is a step forward in this direction.

1.6.2. Water

Lebanon enjoys a relatively good hydrological position. Yearly precipitation is estimated to result in an average yearly flow of 8,600 million cubic meters (Mm^3). This precipitation gives rise to about forty rivers and steams and more than 2,000 springs. Although water seems to be abundant now, shortage could happen in ten to fifteen years if sound and radical water management strategies are not developed and implemented. It is generally accepted that approximately 50% of the average yearly precipitation is lost through evaporation, 8% as surface water flow to neighbouring countries and 12% as ground water seepage. The remaining 30% (2,600 Mm^3) of the precipitation is available for exploitation as surface and ground water. Most of the exploited water in Lebanon is used for irrigation. The MoEW has a ten-year plan for water projects with a budget of US$850 million.

R&D on water management, water recycling and efficient irrigation technologies is very much needed in the coming ten years. Potable natural water could be an industrial sector in Lebanon, if competitive technologies are used for its production and packaging, particularly in the market of the Arab Gulf countries.

1.6.3. Quarries and Cement

According to the *Country Profile-2002* published by the Economist Intelligence Unit (EIU), Lebanon has no commercially exploitable mineral deposits. The post-war construction boom has encouraged open-cast quarrying for marble as well as sand and limestone for cement production. Most of this is domestically consumed, although a modest quantity is exported. However, the industry is facing growing opposition because of its effect on the environment.

Production was increasing until 1996, when it started to decrease. The export of cement is possible if the cost of production is reduced. Introducing new technologies is one of the measures to achieve this goal. Innovations in manufacturing, packaging and shipment are primordial for this industry to be competitive.

1.7. Current Situation of the Tourism Sector

Tourism has traditionally been a significant economic activity in Lebanon. **Figure 5** shows the evolution of tourism in the national economy. Tourism is classified in three major categories:

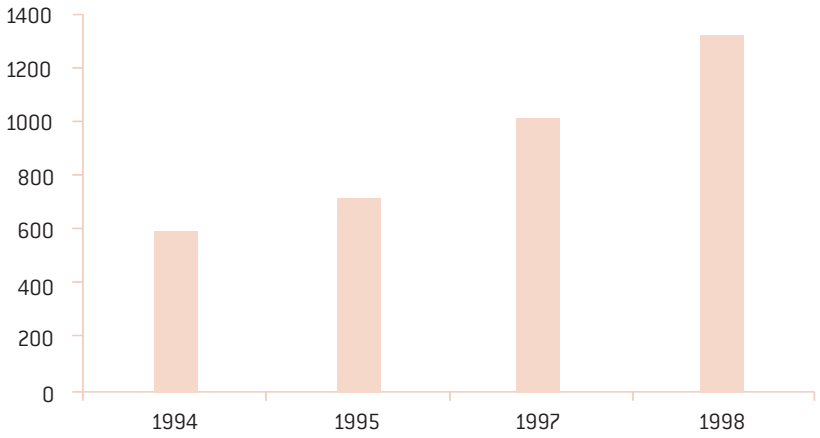
(1) Recreational tourism: beach holidays, summer holidays in the mountains, cultural tourism, adventure tourism and youth activities

(2) Business tourism: exhibitions, congresses and individuals

(3) Other types of tourism: medical, educational and training tourism

Cultural tourism for example, could be developed tremendously in Lebanon, due to historic attractions such as: Baalbeck, Beiteddine, Byblos, Tripoli, Tyre and Saida. The number of visitors to these sites could be improved tremendously.

Figure 5: Tourism in the National Economy (US$ millions)



Source: MoT, Central Ban, CAS (LEDO Indicator # 43)
Ref.: L.S.O.E.R., 2001

Innovation in the tourism sector is a socio-economic need in Lebanon. R&D for the rehabilitation and management of historic sites, environmental management of the costal plain, development of new tourism products, diversification of services and promotion of new marketing technology are all needed axes of intervention.

1.8. Current Situation of the Financial Sector

Financial services in Lebanon constitute an important sector. Banking services used to be the first in the region. This sector is witnessing high competition from other countries in the region, such as Bahrain and Dubai. This sector is also witnessing great technological changes, particularly in e-banking and in new communication technologies, such as General Packet Radio Servise (GPRS). Absorbing these new technologies into the Lebanese financial sector is an urgent need.

On the one hand, billions of dollars are being invested by Lebanese banks outside Lebanon because Return on Investment (ROI) is not high in the Lebanese market, due to the lack of high added value activities. It is well known that high added value economic activities are the result of a production and services sector based on new technologies and innovation. It is estimated that more than one trillion dollars of Arab capital is invested outside the Arab world. Research, Development and Innovation (RD&I) is a prerequisite for attracting investment to Lebanon. This is a long-term process that should be implemented according to a proactive science and technology strategy.

On the other hand, it is well known that the government has a high debt. Inflation averaged around 4% in 2002, largely a result of the introduction of Value Added Tax (VAT), compounded by the higher prices of imported goods following the weakening of the US dollar against the Euro. As the one-off impact of VAT passes, it was expected that consumer price growth would have eased to an average of under 2.5% in 2003-2004.

2. Socio-economic Needs and Priorities

Analysis of major Lebanese socio-economic issues shows certain general needs and challenges that the Lebanese National Innovation System (NIS) should address. These needs should be classified according to priorities based on national, regional and international requirements:

- High and sustained economic growth to reduce national debt
- Job creation to reduce brain drain and unemployment
- High added value economic activities to improve economic growth rate, ensure a high standard of living and attract Foreign Direct Investiment (FDI)
- Increased exports to improve balance of trade
- Better competitiveness of economic sectors to respond to changes due to WTO, AFTA, EU partnership, etc.
- Movement towards knowledge-based economic activities
- Better management of natural resources, particularly water, costal beaches and land
- Protection of the environment to improve tourism/quality of life and to get into emerging environmental industries
- Optimization of energy consumption to reduce cost of energy

3. National Innovation System (NIS): Objectives and Means of Responding to Needs

The NIS is composed, in a simplified conceptual model, of the following components and linkages: education and training, R&D, Technology Transfer (TT), product innovation and development, regional and international cooperation, technical services, information and knowledge dissemination and the production and services sectors.

A long-term vision would give the Lebanese NIS an important role in dealing with the recognized major socio-economic needs. The general objective of the Lebanese S&T policy is to develop an NIS response to socio-economic needs. Namely:

(1) Adopt a holistic approach in the reform of the Lebanese NIS. Missing linkages between higher education, R&D and production and service activities should be established, both in the public and private sectors

(2) Improve the participation of the national education system in Lebanese socio-economic activities. The objective is to have Human Resource Development (HRD) which should lead to less brain drain and better employment of graduates

(3) Improve the national capacity in RD&I to respond to Lebanese socio-economic needs and to contribute to sustained economic growth

(4) Diversify and increase funding of RD&I by means of the following measures:

- Raise funds from public, private, regional and international resources
- Promote legislative incentives for the private sector to encourage its demand for RD&I
- Encourage the creation of venture capital funds and banks

(5) Intensify TT efforts by:

- Improving local transfer between universities, R&D institutes and centres and the production and services sectors
- Improving local negotiation capacity of Lebanese companies for TT
- Improving local capacity in selecting new technologies
- Improving local absorptive capacity for TT, revere engineering and product development
- Regulating TT by avoiding technologies unsuitable for the Lebanese market

(6) Create a favourable environment for S&T and RD&I from the legislative, administrative, fiscal and informational points of view (see below)

4. Institutional Objectives of Lebanese S&T Policy: Needed Linkages within the NIS

For the Lebanese S&T policy to be effective, the NIS should be activated. This can be achieved by establishing strong links between the components of the system. These links are currently either weak or non-existent in Lebanon. These links can be classified in five categories, which are:

(1) Favourable environment: legislative, administrative, social and informational

(2) HRD, especially in under-represented specializations

(3) Institutional cooperation and partnership

(4) Financial links: contractual partnership programmes

(5) S&T planning and monitoring mechanisms

5. Information and Communication Technology (ICT) to Support NIS Performance

5.1. Academic Networks – A Major Component of STIP in Lebanon

Over the past two decades, academic communities all over the world – whether it be higher education institutions, national research institutes and centres of excellence, or industrial research centres – have been striving towards establishing computer networks that link them together in view of the high rate of information exchange within each community and amongst the various communities. Broadband Local Area Networks (LANs) were constructed in buildings and campuses to satisfy the growing need for communication between researchers, professors, students and administrative staff in a given institution; while Wide Area Networks (WANs) linked the various research and teaching institutions in a country. This led to the establishment of national academic networks, such as RENATER in France, that enhance the communication capabilities among national academic communities and help to advance teaching and research capabilities, while simplifying administrative tasks and procedures. These academic networks were also connected to regional backbones and to the Internet with very high throughput to allow for exchange of information with academic communities at the regional and global levels.

A few years ago, efforts were deployed by the UNESCO Cairo Office in the Arab region to build pilot academic networks linking universities and research centres at the national level, following a model that was widespread in European academic communities. Academic networks were planned for Lebanon, Palestine, Syria

and Yemen. The main objective of these projects was the creation of essential infrastructure facilities needed to upgrade higher education programmes, facilitate research and reduce administrative tasks.

5.2. The Lebanese University Network

At the request of the Lebanese Government – partially due to the Lebanese University (LU) locating a networking infrastructure while other private universities already had some networking facilities on their campuses – a UNESCO/Lebanese project focused on establishing a Lebanese University Network (LUN) to connect around twenty campuses and sites (mostly in the Beirut area) forming an Intranet with gateways to the Internet. Funding was mainly provided by UNDP and the Office of Minister of State for Administrative Reform (OMSAR) through its administrative reform project, with some cost sharing by UNESCO and the LU. It was understood, however, that LUN was one component of the Lebanese academic network that needed to be established soon afterwards.

The infrastructure consists of LANs on various campuses, based on structured wiring in buildings (with optical fiber links between buildings) and a WAN linking these campuses. The WAN is based on ring topology and links the major campuses through routers, leased lines and/or wireless connections with star connections for satellite buildings/campuses. A gateway to the Internet exists at the main connection point. Following the intranet model, network servers (i.e. Web, Mail, DNS and Firewall servers) are installed at main locations. The network infrastructure is scalable and flexible in order to grow and develop over time, underpinning all the development and operation of data network services and applications in all LU sites and branches, scattered throughout Lebanon, for the foreseeable future.

5.3. Benefits of an Academic Network in Lebanon

An academic network for Lebanon will facilitate the exchange and sharing of information between the different academic institutions, thus increasing the availability of applications covering teaching and research needs. Electronic information resources having increased in quantity, quality and overall importance over the last decade. The online library catalogues, networked CD-ROM's, bibliographical reference works and electronic journals can be made available by each academic institution to all others, reducing cost and increasing availability. Instant publishing becomes a reality, as well as instant availability of local information on courses, facilities, plans and achievements. This network could also be the basis of e-learning activities, virtual universities, collaborative research and sharing of best practices in teaching and research. In the administrative arena, the network will help universities and the Ministry of Education to exchange information regarding faculty members, employees, student admission and academic life in general.

5.4. Future Prospects

Information technology will redraw the map of education in the next few years. With the ever faster pace of change, academic institutions are facing new challenges to bring their people up to speed, and very quickly. Knowledge navigation becomes more important than knowledge retention. This cannot be done without a sound infrastructure linking together all these institutions, which reduces traffic through the Internet outside the country. The LUN is only the first step on the road to a Lebanese academic network followed by a regional academic network. Other steps will have to follow, such as linking all universities in Lebanon to form a higher education network at the Lebanese level, then connecting research and development institutions to complete the Lebanese academic network. Linkages with other (similar) academic networks on the regional and international levels should follow gradually.

6. New Science and Technology Indicators

Reliable information on Science, Technology and Innovation (STI) capabilities in Lebanon provides essential inputs for relevant policy making aimed at enhancing national competitiveness and productivity. Additionally, sound implementation of STI policies must rest upon reliable information concerning the state of the Lebanese Science and Technology (S&T) systems, as well as regional and international trends likely to impact national competitiveness and productivity.

Traditional S&T indicators, emphasizing supply-side aspects and inputs to national S&T systems are collected and used by a relatively wide range of governmental and academic institutions in many developing countries, including Lebanon. Innovation indicators, on the other hand, constitute novelties to almost all developing countries. While the traditional variety of S&T indicators currently used are certainly of great value in policy and decision making, they may only be of limited utility when dealing with the challenges and opportunities that Lebanon will need to tackle in an increasingly knowledge-based economy with intense global competition across all sectors.

Special note must be made here of ESCWA intentions – in cooperation with concerned regional and international organizations – to act as the hub for a regional network of national units or observatories to monitor STI activity and act as focal points for the establishment of national databases on STI Indicators. As a member country, Lebanon is encouraged to establish its own national STI Observatory, preferably in conjunction with a national network of investment, and is encouraged, as well, to participate in the exchange of data, information and experiences on the implementation of relevant policies and strategies. Training related to the collection and analysis of STI indicators and their incorporation in policy and strategy formulation will clearly be required.

7. Categories of STI Indicators

STI indicators may be grouped into many categories or classes according to a variety of conceptual frameworks. One class of indicators that is used in Lebanon concerns STI human resources and related development activities, such as the number of researchers, universities, their graduates and the projects they engage in. Another class of indicators, designed to appraise R&D activities, includes such indicators as national expenditure on R&D, output produced by national R&D institutions and the effectiveness of linkages between such institutions and others concerned with the utilization of R&D output.

Classification of indicators should consider their position within Lebanon's STI system, as indicators of input, output or processes and linkages. Examples of input indicators include the number of researchers and financial expenditure on R&D. Indicators used as STI output comprise the number of patents and papers published in refereed journals. As for processes and linkages indicators, they may consist of joint research activities, joint publications and research contracts. On the other hand, indicators addressing the impact of STI activities on economic performance include revenues generated by high technology enterprises or the export of high technology products in comparison to total exports.

Another system of classifying STI indicators depends on the nature of national activities undertaken relating to whether that activity targets the creation, dissemination, transfer or utilization of STI knowledge. This classification system may be more suitable for adoption in Lebanon, considering the present state of its STI development, which is characterized by considerable separation of the aforementioned activities at the level of institutions and resource allocations.

Immense technological change is currently transforming the global economy with respect to a number of disciplines in S&T. More specifically, new Information and Communications Technologies (ICT) have introduced a multitude of changes in the innovation of countries and institutions to achieve a competitive edge. Therefore, it is essential to utilize indicators that describe national and enterprise performance in ICTs as users and developers.

Any sector in Lebanon's economy is capable of innovating, however, innovation taking place at the enterprise level is considered the most valuable for direct benefits targeting national growth and competitiveness. Hence, attention has recently focused on evaluating innovation at the level of the individual enterprise. Some possible innovation indicators include the proportion of 'innovating' firms, as opposed to the 'non-innovating' ones, the impact of innovation or the percentage of sales derived from innovative products, as well as other indicators relevant to the measurement of innovation, such as resources devoted to R&D.

8. Elements of Science and Technology Indicators

8.1. Research and Development Indicators

The capacity to undertake innovation activities is directly related to national R&D activities in Lebanon. The general tendency in R&D assessment has been to emphasize quantitative input indicators over output indicators. The complexity of estimating R&D output has incited wider use of indicators such as: expenditure on R&D, number of R&D personnel and the number of R&D projects in a particular area. Related indicators have also been assembled on the basis of the former two indicators (e.g. number of researchers per project in a particular area, annual expenditure per researcher and per project, etc.). **Frame 1** presents indicators providing information on a country's support for and performance in R&D.

Frame 1: Indicators Providing Information on a Country's Support and Performance in R&D

Business Enterprise R&D Expenditure (BERD): Accounts for contributions to R&D activity made by firms, organizations and institutes that primarily produce goods and services[4] for sale to the general public, as well as the non-profit private institutions that service them. Contributions to R&D by public sector enterprises are also included within this category.

Government R&D Expenditure (GOVERD): Incorporates R&D expenditure by agencies, offices and other entities that offer public goods and services[5], as well as those that oversee governmental, economic and social policies of the country or community in question. This indicator also includes expenditure by non-profit institutions funded and directed by the government.

Higher Education R&D Expenditure (HERD): Accounts for R&D expenditure by higher education institutions, such as universities and colleges, irrespective of their source of funding or degree of dependence on public policies or legal profile. This is also inclusive of expenditure by research centres, experimental stations and clinics that operate under the wing of higher education institutions or are affiliated with such institutions.

Private Non-Profit R&D Expenditure (PNPERD): Includes expenditure by non-profit institutions that serve the public sector as well as those by individual donors to R&D activity.

Extra-National Contributions: Refers to contributions by organizations and individuals resident abroad[6]. This would include international organizations and any physical assets and activities they may deploy within national borders.

Source: Economic and Social Commission for Western Asia (ESCWA). New Indicators for Science,Technology, and Innovation in the Knowledge-Based Society, 2003. (E/ESCWA/TECH/2003/7)

From a quantitative point of view, R&D output can be measured through an assessment of the knowledge embodied in published scientific discoveries and technological innovations, as well as through sources of information that detail published research reports and patents. However, the creation of knowledge that stems from R&D activities is more difficult to measure.

8.2. Bibliometrics

Mathematical and statistical analysis of scientific publications may be conducted to study the extent and distribution of scientific output in a given field in Lebanon, as well as the contributions of specific institutions or individuals. Bibliometric indicators generally focus on the output of research activity undertaken primarily in universities and research centres. They address both the quantity and the quality of such activities. In common with other indicators, they are significant only in a comparative sense.

Bibliometric indicators commonly use a full-counting scheme of publications grouped by countries or regions. Otherwise, they may consider the distribution of periodicals across different scientific fields. It is also possible to combine several citation impact indicators into more complex indices.

8.3. Intellectual Property Indicators

Patenting is used as a primary tool by firms and individuals to protect their production and receive royalties on production and services activities based on an innovative concept. The number of patents granted in a given sector to a particular institution or to researchers in a given discipline, within a given country, is useful as an indicator of institutional and national contributions to innovation in that sector or discipline.

Based on data collected through patent offices, it is possible to extract several variables pointing to the extent and level of patenting activity.

These variables are relatively straightforward and provide valuable information that can primarily be used in economic, business and policy analyses. Such analyses may be further enriched by incorporating economic and social variables leading to indicators that address:

- Productivity
- Determinants of technological advance
- Spillovers/knowledge flows
- Technology foresight

8.4. Higher Education Indicators

A set of widely used S&T input indicators is utilized in Lebanon to evaluate the performance of higher education institutions and their contribution to the accumulation of skilled human resources and intellectual capital.

Both input and output elements should be used to analyze information on higher education and vocational training. Indicators less frequently used are those that refer to the quality of higher education, although they are exceptionally important and deserve a greater amount of attention. Assessing the quality of higher education requires consideration of a broad perspective of life-long learning, rather than restricting focus to the current labour market.

Output indicators in higher education frequently refer to the number of graduates in different areas of specialization. The quality of the higher education system in Lebanon is measured by course completion rates across disciplines and areas of specialization and the success rates in acquiring jobs at the end of the higher education courses. Note that the latter is an indicator of the prevailing general economic conditions and of the supply and demand of specialized professionals of a particular economy. **Annex II** (page 216) of this chapter provides available statistics on Lebanon in relation to selected indicators.

9. Innovation Indicators

The development and diffusion of new technologies in Lebanon plays a central role in securing improved productivity and competitiveness. However, despite the importance of scientific and technological innovation, understanding the processes that lead to innovations and to their dissemination is still deficient. As a result, the impact of technological changes is dealt with implicitly by planners and decision makers and is not normally reflected in reporting on Lebanese total factor productivity and in output growth rates.

While innovations can occur in any sector of the economy, those that take place at the enterprise level have been credited with enormous benefits for national economic growth. Therefore, attention is usually focused on evaluating innovation in the business enterprise sector and at the level of individual firms, as well as activities related to enterprise creation, incubation and promotion activities undertaken in Lebanon's universities and research centres.

9.1. Technological Product and Process (TPP) Innovation

In general, introducing TPP innovation involves activities on a wide front aimed at securing inputs of scientific, technological, organizational, financial and commercial origins. Often, a whole collection of such inputs will play an important part in producing conditions that eventually allow implementation of technologically new or improved products or processes.

TPP innovation may be regarded as such only if it has been implemented, i.e. if it has actually been introduced into commercial application (in the case of product innovation), or used within a production process (in the case of process innovation). On the other hand, innovative firms may be engaged in ongoing innovation, where innovative activities are in progress but have not yet reached a stage of commercial implementation.

9.2. International Trade in High Technology

A country's trade activity in high technology provides insight into its competitiveness. One indicator that may be used in Lebanon is the percentage of trade in high technology goods with respect to Lebanon's total exports. This indicator can be evaluated at the sectoral level or the product level.

10. Information, Communication and Technology Indicators (ICT)

The importance of ICT infrastructure and capabilities in general cannot be over-emphasized. In particular, indicators are required to point out progress achieved in ICT dissemination through higher educational and vocational training, as well as capabilities being established for ICT research and development activities, in addition to the extent of dissemination of selected ICT applications. **Frame 3** lists relevant indicators in addition to selected statistics on Lebanon's ICTs.

Frame 3: Information and Communication Technology Indicators: Definitions and Statistics

The World Bank defines ICTs as, "the set of activities which facilitate by electronic means the processing, transmission and display of information". By improving communication, ICTs promote information sharing and the accumulation of knowledge. However, there are barriers that hinder the effective diffusion and implementation of ICTs in Lebanon, such as computer illiteracy.

Indicators allow for comparison of ICT capacity building among countries in reference to defined criteria. However, in order to fully appreciate the significance of values associated with particular indicators, it is necessary to consider a number of related social and economic parameters. Nevertheless, an important starting point is to collect data on indicators at the national level as a prelude to their analysis in relation to socio-economic and other factors. **Table 8** (page 212) shows a list of the adopted ICT indicators whereas **Table 9** presents some statistics on ICTs in Lebanon.

Source: Economic and Social Commission for Western Asia (ESCWA). New Indicators for Science, Technology, and Innovation in the Knowledge-Based Society, 2003. (E/ESCWA/TECH/2003/7)

Table 8: ICT Indicators

Index/ Dimension	Indicators	Sources
Connectivity	Internet hosts per capita Number of PCs per capita Telephone mainlines per capita Cellular subscribers per capita	International Telecommunications Unions (ITU)
Access	Internet users per capita GDP per capita	ITU World Bank
Policy	Presence of Internet exchange Competition in local loop telecom Competition in domestic long-distance Competition in Internet service Provider (ISP market).	UNCTAD research ITU ITU ITU
Other	Network readiness index ICTs in education	Harvard University

Source: Adapted from United Nations Conference On Trade and Development (UNCTAD). Information and Communication Technology Development Indices, 2003

Table 9: Selected ICT Data in Lebanon, 2002

Country/ Region	Main Telephone Lines per 100 Inhabitants	Cellular Subscribers per 100 Inhabitants	Personal Computers per 100 Inhabitants	Internet Users per 100 Inhabitants	Top-Level Domain names per 10,000 Inhabitants
Lebanon	19.88	22.7	8.05	11.713	21.08
ESCWA member countries	19.45	25.27	10.93	6.67	10.71
Arab World	13.47	17.69	6.72	4.57	7.04
World	18.04	18.77	9.22	9.72	238.26

Sources: ITU World Telecommunication Indicators Database, 6th edition, 2002; ITU Arab States Telecommunication Indicators, 2000

11. Conclusion

Over the past few decades, significant progress has been made in monitoring national STI capabilities. New and more complex indicator systems were developed through improved understanding of the paths taken by scientific and technological development, their impact on innovation, and through this, on national competitiveness and productivity. Indicators that enable monitoring of some of the more complicated aspects of the relationship between STI capacity, national growth and competitiveness are now in use in all developed and most industrializing countries around the world.

Mastering the ability to use such indicators will be crucial for Lebanon's socio-economic policy and decision making. National development strategies will be in greater need, than ever before, for these improved tools to evaluate the status of Lebanon's STI capabilities, forecast future prospects and institute appropriate measures to achieve desired changes. Attempts are being made in Lebanon to devise strategies aimed at enhancing national STI capabilities. These strategies should allocate top priority to overcoming obstacles to effective STI monitoring and evaluation. Two of the main difficulties often encountered in Lebanon in this regard are:

(1) Lack of institutional arrangements dedicated to STI monitoring and evaluation

(2) Limited degree of agreement among institutions on common definitions for some of the main entities addressed in STI performance evaluation exercises

There is pressing need to set up a national STI Observatory in Lebanon dedicated to monitoring STI capabilities. This Observatory should be an integral part of the design of a national STI policy and the implementation of strategies. It is suggested that this Observatory be hosted by the CNRS.

Monitoring the evolution of STI capabilities may certainly be facilitated by developments in ICT. It should thus be possible to set up specialist statistical units, within universities and departments of education, at the national and district levels to carry out collection and initial analysis of information relevant to their scope of activities which then could be used in implementing policy and institutional change. Similar arrangements should be possible, with minimal expenditure of costs and manpower efforts, in regard to entities engaged in monitoring and licensing industrial enterprises related to issues of technology transfer and utilization activities, product and process innovations, etc. Similar activities may be undertaken by agricultural extension services in monitoring STI related activities. It is necessary for local efforts in Lebanon to move towards internationally adopted systems of indicators and analysis methodologies.

In summary, greater efforts need to be exerted in Lebanon to collect and analyze statistics and other information on the evolution of its STI capabilities. Further manpower, financial and institutional resources will be required to:

- Develop a national system of indicators that reflects national aspirations and particularities, while maintaining emphasis on compatibility with regional and international metrics
- Establish units dedicated to the development and implementation of STI indicators as part of efforts to review and update national STI policies
- Allocate resources for training activities, capacity building, development of software packages, etc. that would standardize the use of STI indicators

Annexes

I. Key Indicators

Surface area (thousand sq. km)	10.4
Population (millions), 2001	3.6
Population (average annual percent growth), 1990-2000	1.8%
Life expectancy at birth, 2000	
Male (years)	69
Female (years)	72
Adult illiteracy rate (%), 2000	
Male	8%
Female	20%
Gross tertiary enrollment ratio, 1998 or most recent year	38%
Gross domestic product (US$ billion), 2001	16.7
Gross domestic product (average annual percent growth), 1990-2000	6.0%
Gross national income per capita (US$, PPP), 2000	4,550
Growth of output (average annual percent growth), 1990-2000	
Agriculture	1.8%
Industry	-1.6%
Manufacturing	-4.3%
Services	4.1%
Inflation (annual percentage change), 2001	0
Unemployment (percent of total labour force), 1997	8.6%
Gross national savings rate (percent growth), 1990-2000	-2.7%
Gross capital formation (percent of GDP), 2000	18.0%
Household final consumption (percent of GDP), 2000	87.8%
Current government revenue (ex. grants, % of GDP), 2001	18.6%
Total government expenditure (% of GDP), 2001	35.5%
Overall budget deficit/surplus (% of GDP), 2001	- 16.9%

Highest marginal tax rate, 2001	
Individual	20%
Corporate	15%
Money and quasi money (annual percent growth), 2002	9.8%
Domestic credit provided by the banking sector (% of GDP), 2000	183.4%
Stock market capitalization (US$ million), end 2001	1.228
Exports of goods (US$ million), 2001	889
Imports of goods (US$ million), 2001	7,291
Net energy imports (percent of commercial energy use), 1999	97%
Current account balance (% of GDP), 2001	-27.1%
Foreign direct investment inward stock (US$ million), 2000	998
Foreign direct investment (% of gross capital formation), 2000	10.0
Total international reserves minus gold (US$ million), end 2001	5,013.8
Total international reserves minus gold (months of import coverage), 2001	8.3
Total foreign debt (US$ million), 2001	15,143
Long-term debt (US$ million), 2001	12,167
Total debt service (% of GDP), 2001	10.5%
Total foreign debt service paid (percent of exports of goods), 2001	196.2%
Sovereign long-term foreign debt ratings, July 2002	
Moody's	B2
Standard and Poors	B-
Real effective exchange rate (1997=100), 2001	106.9

Sources: The Heritage Foundation 2002, Index of Economic Freedom; World Development Indicators 2002; IMF International Financial Statistics 2002; IMF World Economic Outlook Database, April 2002: Economist Intelligence Unit; UNCTAD FDI Statistics.

Values greater (less) than 100 indicate appreciation (depreciation)
Ref.: AWCR (2002-03)

II. Selected Data on Higher Education in Lebanon[1]

Higher Education Infrastructure

Most ESCWA member countries, including Lebanon, show an even distribution between the number of S&T and H&SS colleges. The most recent statistics on the number of students and staff in Lebanon and other countries do not all belong to the same year as shown in **Table A.1**. For comparison purposes, the student/staff ratio is of more significance than the actual numbers; that of Lebanon was twelve students per staff member in 1999.

Table A.1: Higher Education Student to Staff Ratio in Lebanon and Selected Arab Countries

Country	Academic Year	Student to Staff Ratio
Lebanon	1999	12
Oman	2001	10
United Arab Emirates	1998	14
Yemen	2000	43

Source: Adapted from ESCWA, Statistical Abstract of the ESCWA Region (E/ESCWSTAT/2002/6).

Higher Education Expenditure[2]

One of the most significant input factors is expenditure on higher education, usually reported per capita or as a percentage of the country's GDP. Total higher education expenditure in the Arab countries amounted to US$ 6,976.7 million in 1996. **Table A.2** shows higher education expenditure in the Arab countries as a percentage of GDP for 1996. As a whole, Arab countries allocated an average of 1.25% of their GDP to higher education expenditure in 1996. A majority of ESCWA member countries allocate a medium to high portion of their GDPs to higher education expenditure, Lebanon falls within high, higher education expenditure as a percentage of GDP at 2.0%.

Table A.2: Higher Education Expenditure as Percentage of GDP in Arab Countries, 1996

High: Above 1.5 %		Medium: 1.0 – 1.5 %		Low: Below 1.0 %	
Jordan	3.1 %	Sudan	1.4 %	Qatar	0.8 %
Palestine	2.3 %	Algeria	1.4 %	Iraq	0.5 %
Lebanon	2.0 %	Syrian Arab Republic	1.3 %	Djibouti	0.4 %
Saudi Arabia	1.8 %	Yemen	1.3 %	Libya	0.4 %
Egypt	1.6 %	Morocco	1.2 %	United Arab Emirates	0.3 %
		Bahrain	1.1 %	Somalia	0.2 %
		Kuwait	1.1 %		
		Oman	1.1 %		
		Tunisia	1.1 %		
		Mauritania	1.0 %		

Note: ESCWA member countries are in red.

Source: Adapted from ESCWA-UNESCO, Higher Education Systems in the Arab States: Development of Science and Technology Indicators (E/ESCWA/TECH/1998/3).

Higher education expenditure per student is another indicator that is useful to assess a country's investment in higher education. The values for Lebanon and other selected Arab countries in 1996 are shown in **Table A.2** (page 217). The expenditure in higher education per student in Lebanon was about US$3,100 whereas that of Saudi Arabia was at a value slightly lower than $10,000. The higher education expenditure per student in Yemen, on the other hand, had a much lower value at about $500, indicating a low investment in higher education.

Table A.3: Higher Education Expenditure per Student in Lebanon and Selected Arab Countries, 1996

Country	Higher Education Expenditure per Student (US$)
Lebanon	3087.3
Oman	9539.0
Saudi Arabia	9946.2
Yemen	515.0

Source: Adapted from ESCWA-UNESCO, Higher Education Systems in the Arab States: Development of Science and Technology Indicators (E/ESCWA/TECH/1998/3).

Student Enrolment and Graduates

Student enrolment, particularly at the Bachelor level, in the Arab region has been on the rise over the last decade. Master and Ph.D. students have also increased, but are still quite low, partly because not all universities in the region possess the necessary capabilities, in terms of qualified faculty members, course material and equipment. **Table A.4** presents the number of university students in Lebanon and selected Arab countries in 1996, whereas **Table A.5** gives the number of higher education students in more recent years.

Table A.4: University Students and Graduates in Lebanon and Selected Arab Countries, 1996

Country	Bachelor		Master		Ph.D.		Total	
	Students	Graduates	Students	Graduates	Students	Graduates	Students	Graduates
Egypt	836,055	91,511	43,204	5,984	20,522	3,421	**899,781**	**100,916**
Lebanon	71,220	9,501	2,506	666	590	116	**74,316**	**10,283**
Qatar	7,477	1,289	78	23	57	10	**7,612**	**1,322**
United Arab Emirates	14,691	1,691	213	57	294	53	**15,198**	**1,801**

Source: Adapted from ESCWA-UNESCO, Higher Education Systems in the Arab States: Development of Science and Technology Indicators (E/ESCWA/TECH/1998/3).

Table A. 5: Number of Higher Education Students and University Graduates in Lebanon [3]

	1997	1998	1999	2000	2001
University graduates	11,422	11,298	12,895	14,742	-
Higher education students	87,957	87,330	101,440	103,869	119,487

Source: ESCW A. Statistical Abstract of the ESCWA Region. 2002. (E/ESCWA/STAT/2002/6)

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IV. Endnotes

IV-i Report

[1] The Lebanese University is the public institution for higher education in Lebanon. Scattered around the country are forty-eight sites, 3,000 full-time faculty members, 2,000 part-time faculty members, 2,000 staff members and a student body numbering over 65,000 individuals. This number is expected to grow quickly due to the economic conditions and to high fees in private universities (where fees/year are between US$6,000 and $14,000, exceeding by far the average GNP of the country).

[2] For a detailed treatment of these notions see the ESCWA *Study on Science and Technology Indicators – Basic Concepts, Definitions and Prospects for Development,* 1997 (E/ESCWA/TECH/1997/6).

[3] One of the limitations of the data collected for estimating resources devoted to R&D is the fact that being an input, it does not measure technical change, and as such, falls short of including factors such as learning-by-doing.

[4] Excluding higher education.

[5] Excluding higher education.

[6] With the exception of the cars, ships, airplanes and space satellites that are operated by domestic organizations and the experimental locations of these organizations.

IV- ii Annexes:

[1] The material in this section is taken from: ESCWA, *New Indicators for Science, Technology, and Innovation in the Knowledge-Based Society,* 2003 (E/ESCWA/TECH/2003).

[2] Unfortunately, not all statistics on higher education systems in the Arab countries are available after 1996, further illustrating the obvious inadequacies in statistical resources in the region.

[3] Higher education institutions include university and other higher education institutions.

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