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SCIENCE AND TECHNOLOGY POLICY IN LEBANON

INITIATIVES AND RELEVANT INDICATORS

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I. RESEARCH AND DEVELOPMENT ACTIVITY IN SOME ESCWA COUNTRIES

Policymakers around the world are developing strategies to take advantage of the technology-based economy. Areas that thrive will boast a strong and vibrant research and development base. For Lebanon to develop that base, it must understand what sectors comprise the Lebanese R&D base and what elements are needed for a technology-based economy. In general, a simplified conceptual model of a national innovation system (NIS) is that it is composed of the following components and of effective linkages between these components: education and training, R&D, technology transfer, product innovation and development, regional and international cooperation, technical services, information and knowledge dissemination, and the production and services sectors.

This section presents a brief general idea of the R and D activity in some ESCWA countries. In fact, some of the most commonly used indicators of R and D activity cover quantitative inputs, namely the number of scientists employed in R and D departments, expenditure per project and per researcher, overall investment in the purchase of new equipment and in building new facilities, and time allocated for a project completion. On the output side, the preference for indicator usage varies among countries. In ESCWA member countries, the prevailing tendency is to evaluate results of R and D in terms of expected savings achieved through improved products and processes. Some efforts have been devoted to grade the R and D output in terms of conformity with planning parameters and initial expenditure, and time-to-delivery estimates. Nevertheless, the limitation of these methods has been the lack of indicators to measure the quality of the final product. Statistics for selected R and D indicators are briefly presented below[2]. Note, however that the numerical values for indicators listed below need to be updated on the basis of more recent surveys.

Full Time Equivalent (FTE) Researchers: The distribution of full time researchers in the Arab countries for 1996 shows that the majority, around 44 per cent, converges on agricultural research. This is mainly due to the fact that most Arab countries have an important agricultural economy. Lebanon, for example, allocated almost 31% of its FTE workforce in this field. Engineering researchers in 1996 were most prevalent in the Syrian Arab Republic, at 32 per cent of total researchers. Meanwhile, Lebanon had 24 per cent of its FTE researchers dedicated to the basic sciences. See Table 1.

R and D expenditure: The R and D expenditure in the majority of the ESCWA member countries were in the range of $3 million to $70 million. Lebanon falls at $7.5 million in that range. An obvious exception is Egypt that had R and D expenditure value of $227.5 million. See Table 2. The R and D expenditure per FTE researcher is a more valuable indicator that allows suitable comparisons among countries. The highest value of R and D expenditure per FTE researcher was that of Saudi Arabia with a value of $231,800.

TABLE 1: NUMBER AND PERCENTAGE OF FTE RESEARCHERS BY R AND D AREA, AND THEIR DISTRIBUTION FOR EACH OF THE ARAB COUNTRIES IN 1996

Country	Agriculture		Health		Industry		Basic Sc.		Education		Engineering		Energy		Petroleum		Econ.		Res. Mngmt.		**Total**
	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	Nr.	Pct.	
Egypt	5221	48.6	1827	17.0	871	8.1	751	7.0	523	4.9	471	4.4	509	4.7	236	2.2	102	0.9	233	2.2	**10,744**
Syria	124	34.8	30	8.4	13	3.7	15	4.2	39	11.0	112	31.5	20	5.6	0	0.0	3	0.8	0	0.0	**356**
Lebanon	63	30.7	32	15.6	4	2.0	45	22.0	22	10.7	14	6.8	12	5.9	0	0.0	8	3.9	5	2.4	**205**
Qatar	0	0.0	0	0.0	2	5.9	8	23.5	13	38.2	4	11.8	0	0.0	0	0.0	5	14.7	2	5.9	**34**

[2] The material in this section is taken from: ESCWA. New Indicators for Science, Technology, and Innovation in the Knowledge-Based Society, 2003. (E/ESCWA/SDPD/2003/5)

Source: ESCWA-UNESCO. Research and Development Systems in the Arab States: Development of Science and Technology Indicators, 1998. (E/ESCWA/TECH/1998/3)

TABLE 2: R & D EXPENDITURE AND NUMBER OF FULL-TIME EQUIVALENT RESEARCHERS AND SUPPORT STAFF IN 1996

State	R and D expenditure (Millions of US dollars)	Number of FTE researchers	Number of FTE researchers per 100 000 population	Number of R and D support personnel	Number of R and D support personnel per 100,000 population	Ratio of R and D expenditure to the number of FTE researchers (thousands of US dollars)
Lebanon	7.45	205	6.6	239	7.7	36.4
Saudi Arabia	196.1	846	4.5	1,575	8.4	231.8
Yemen	10.3	270	2	771	4.8	38.1
Total in ESCWA member countries	611.67	14 962	10.3	34 475	23.7	40.9

Source: Adapted from ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/3).

Frame 1 presents statistics on Science and Technology papers published in the ESCWA member countries.

Frame 1. Science and Technology Papers Published in the ESCWA Member Countries

The number of science and technology papers published in refereed international journals have increased in the last twenty years from a total 5,865 in the period 1970-1975, to 34,594 during 1990-1995. Egypt and Saudi Arabia are the most prolific in absolute terms; together they produced almost 74 per cent of all papers published in the Arab region between 1990 and 1995. Lebanon is the only county in the region whose publishing output decreased from 743 during 1970-1975, to 500 during 1990-1995. See . Nevertheless, the number of citations received by these published articles is very small. The latest figures published by the Arab Human Development Report 2002 indicate that only four papers from the region are cited more than 40 times, almost negligible compared to the thousands of articles from the United States of America cited the same number of times.

FIGURE 1. NUMBER OF TECHNOLOGY OUTPUTS AND PAPERS PUBLISHED IN ESCWA MEMBER COUNTRIES

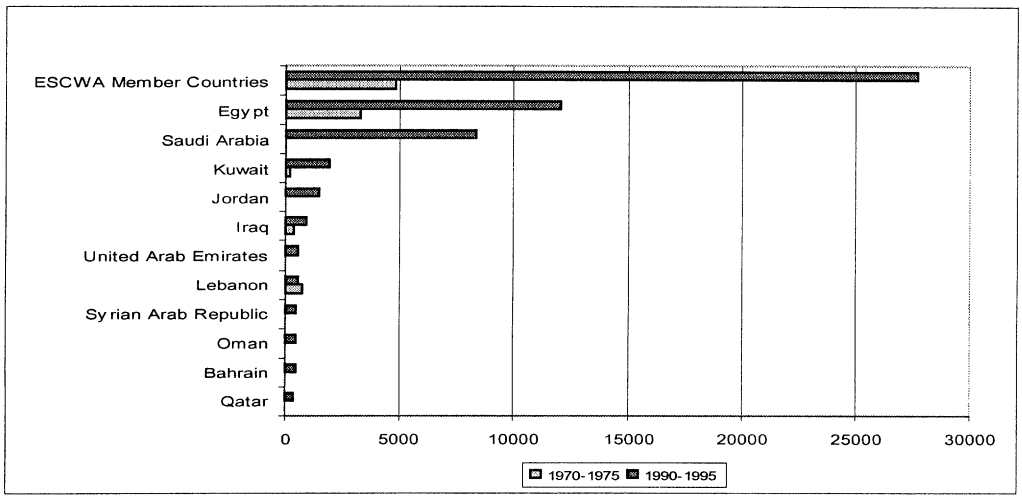

Figure Source: UNDP, Arab Human Development Report 2002.

Source: Economic and Social Commission for Western Asia (ESCWA). New Indicators for Science, Technology, and Innovation in the Knowledge-Based Society, 2003. (E/ESCWA/SDPD/2003/5)

II. SCIENCE AND TECHNOLOGY POLICIES IN LEBANON

A. CURRENT STATUS

Lebanon's National Council for Scientific Research (NCSR), established in 1962 and directly linked to the Prime Minister's Office, drafted Lebanon's first science policy in 1966. Although Lebanon was one of the first ESCWA countries to embrace the concept of a national Science and Technology (S&T) policy, the draft document for such a policy was never formally approved[3].

The original science policy was revised by the Board of Directors of NCSR in 1994. Comments and suggestions on the draft policy were invited from concerned ministries and institutions prior to its finalization. In 1995, NCSR produced a new draft national science policy, which was eventually submitted to the government for approval and adoption. Apart from a few amendments, the plan is essentially based on the initial policy.

The NCSR work plan for 1999 took its cue from the general guidelines of the new science policy. The intention is nonetheless to produce a five-year implementation plan, in collaboration with the concerned directorates and institutions, once the policy document is officially adopted. A final draft has recently been prepared by the NCSR and it is under study for final approval.

B. OBJECTIVES OF LEBANON'S SCIENCE POLICY

In view of the lebanese statistics on R and D indicators presented earlier in this document, it is obvious that there is need for the rational development of Lebanon's scientific potential and the utilization of research results for improving social and economic conditions. This was one of the principal aims of Lebanon's first national science policy, as outlined in the draft policy document issued by the National Council for Scientific Research (NCSR). The general objectives of policy included:

(a) Promotion of scientific research in areas related to reconstruction and development in industry, social and economic affairs, and public health and the environment;

(b) Providing infrastructure support and resources for scientific research, including the establishment of laboratories and the supply of equipment, manpower training, and research grants and assistantships;

(c) Rationalization of the utilization of natural, human, economic and cultural resources, beginning with relevant surveys, and conducting studies and research programmes aimed at the discovery of new resources and optimal methods for their utilization;

(d) Retrieving Lebanon's cultural and scientific roles with a view to counteracting the country's limited natural resources, a task which will necessarily entail focusing on its human resources and on the promotion of scientific research as a means of improving productivity.

The science policy project document entrusts NCSR with responsibility for conducting surveys of Lebanon's resources in scientific research, analysing information concerning science policy developments at the global level as well as organizing programmes aimed at enhancing the capabilities of human resources in scientific research and information exchange with research partners abroad.

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[3] For more details, see an ESCWA study entitled *Science and Technology Policies in the Twenty-First Century* (New York: United Nations, 1999).

The document proposes that 1 per cent of Lebanon's GDP should be earmarked for implementation of the country's science policy, and that this percentage should subsequently be gradually raised to 3 per cent.

Actions that should be taken with respect to policy implementation are outlined in the document. In essence, NCSR is to draft five-year plans constituting the basis for resource allocation and human resource training development. An interesting feature of Lebanon's science policy document is that it addresses the issue of "un-directed" or basic research efforts. Such research is encouraged, and grants may be made available to Lebanese researchers for conducting it. NCSR's work on a national science policy for Lebanon has resulted in a number of recommendations, which are being discussed at national and international fora. Some of the main recommendations are listed in Frame 2.

Frame 2. Recommendations to be considered at the national level in future stages of science policy work by NCSR in Lebanon

1. Securing steady budgetary support for the entire duration of the executive plan.
2. Enhancing co-ordination with concerned institutions in formulating relevant plans and the execution of those plans.
3. Raising awareness in private enterprise circles of the importance of technological innovations that may be achieved through support for domestic research activity.
4. Creating technical research centres within universities, along the lines of the recently established "Institut Universitaire de Technologie" at the Lebanese University, with a view to enhancing the level of research and specialized technical services made available to the private sector.
5. Encouraging universities to take the initiative in re-orienting their teaching and research programmemes to build bridges towards national industry.

A long-term vision for the Lebanese NIS is that it should play an important role in dealing with the recognized major social and economic needs. The general objectives of the Lebanese S&T policy that will create a National Innovation system (NIS) responding to the social and economic needs are:

1) Adopt a holistic approach in the reform of the Lebanese NIS. Missing linkages between higher education, R&D and "production and services" activities should be established, both in the public and private sectors. This objective could be achieved through:

- Coordinating national sectoral policies with the S&T policy;
- Promoting partnerships, networking and clustering between the different components of the NIS;
- Encouraging the creation of NIS linking mechanisms and institutions, such as: science parks, technology incubators, centers of excellence, cooperative research centers, venture capital funds;
- Helping the private sector to participate in national R&D and S&T activities.

2) Improve the participation of the national educational system in the Lebanese social and economic activities. The objective is to have a Human Resources Development (HRD), which should lead to less brain drain and better employment of graduates. This is achievable through:

- Ensuring an education curricula more relevant to Lebanese market demand;
- Establishing contact with expatriates abroad in order to solicit their participation in the reconstruction and development of the country;
- Establishing effective private and public employment agencies, and a national programme aiming specifically at employment of graduates;
- Elaborating a manpower plan that identifies the skill and specialization needs of the Lebanese labour market in the next five to ten years. Such a plan would permit proper counseling of students as to career opportunities;

- Introducing incentives for students to move into the type of training most needed by the Lebanese economy;
- Promoting a better distribution of education institutions between Mohafazats, to reduce migration of working age population from villages and towns towards the city or towards other countries;
- Promoting R&D in Lebanese universities and adopt a proactive Masters and PhD programmes in cooperation with the private sector.

3) Improve the national capacity in Research and Development and Innovation (R&DI) to respond to the Lebanese social and economic needs; and to contribute to a sustained economic growth. This objective is realized through the following policies:

- Adopt a national programme to support the private sector demand of R&DI, and to support the cooperation of this sector with national higher education and R&D institutions;
- Create new R&D units, related to Lebanese social and economic needs, and render more support to existing ones;
- Create intermediate institutions to link R&D and higher education to the market, such as: science parks, incubators, centers of excellence, venture capital funds, cooperative R&D centers and laboratories between the private sector and R&D institutions;
- Promote Lebanese capacity in product development: reverse engineering, technology transfer, CAD/CAM[4], physical design;
- Increase the number of R&D staff in Lebanon.
- Increase expenditure on R&D

4) Focus on three major R&D axes: (1) basic sciences, industrial technologies and engineering sciences; (2) environmental sciences, agriculture and biological sciences; (3) medical sciences and public health.

- Adopt national R&D programmes in the major three axis that would:
  - Improve the technologies of already existing sectors;
  - Create new sectors based on new technologies;
  - Anticipate for the transfer and adoption of emerging technologies.

- R&D in the first axis would focus on
  - Application of Total Quality Management (TQM) in Lebanese industries; and adoption of international industrial standards, to ensure that Lebanese products and services will be in conformity with these standards;
  - Creation or linkages of industrial and technological databases or information systems related particularly to Lebanese production and services sectors;
  - Automation technologies for production lines, particularly for major Lebanese industrial sub-sectors, namely: textiles, metal, and agro-industries;
  - Information and Communication Technology (ICT) applications in the Lebanese financial sector, particularly new technologies such as GPRS telecommunication which is expected to introduce major drastic changes in this sector. This important sector in the Lebanese economy is now not as competitive as it used to be;
  - Building Lebanese absorptive capacity of new technologies and new industrial sector such as ICT, electronics, advanced and new materials, and mechatronics;
  - Renewable energies, energy management, and energy conservation.

- R&D in the second axis would focus on:
  - Water management both surface and underground, and the use of ICT in this field;

[4] Computer Aided Design/ Computer Aided Manufacturing

- Waste, water and air recycling technologies and industries;
- New technologies for agro-industries including new packaging techniques;
- Biotechnology for agricultural applications;
- Application of ICT in Lebanese tourism.

- The 3rd axis would include R&D on:
  - Selected pharmaceutical fields. The selection should be driven by the Middle East market, and based on the high technical human resources available in Lebanon;
  - Capacity building in medical services. Lebanon had a comparative advantage in the Arab world in this respect. This status could be restored. "Medical Tourism" could be a successful field of this sector in Lebanon;
  - Selected biomedical fields and industries;
  - Devices particular to the region;
  - E-healthcare on the regional level.

5) Diversify and increase funding of R&DI by means of the following measures:
- Raise funds from public, private, regional and international resources to augment the Gross Domestic Expenditure on R&D to a higher percentage of the Lebanese GDP;
- Promote legislative incentives for the private sector to encourage its demand of R&DI;
- Adopt national programmes to encourage industry-university cooperation in R&DI;
- Encourage the creation of venture capital funds and banks;
- Increase the Lebanese efforts to profit from regional and international aids for R&DI.

6) Intensify Technology Transfer (TT) efforts by:
- Improve local TT between universities, R&D institutes and the production and services sectors;
- Improve local negotiation capacity of Lebanese companies for TT;
- Improve local capacity in selecting new technologies;
- Ameliorate local absorptive capacity for TT, revere engineering, and product development;
- Regulate TT by avoiding unsuitable technologies for the Lebanese market.

7) Create a favorable environment for S&T (R&DI) from the legislative, administrative, fiscal and informational point of view.

III. TECHNOLOGY INITIATIVES IN LEBANON

A. Educational And Training Initiatives

The Lebanese private sector is active in new technologies and has initiated projects and activities with academic as well as public-sector institutions. Specifically, a technology-related initiative has been launched in February 2001 by LibanCell, a leading GSM service provider, under the name "LibanCell Educational Support Programme". In recognition of the crucial role of qualified human resources and capacity-building in development, this programme focuses on education and training as well as R and D in the telecommunications field.

Partnership with educational institutions is a cornerstone of the Educational Support Programme, with the aim of "developing the talents and capabilities of Lebanese youth and providing them with the

background they require in order to excel in the field of communications technology."[5] This initiative is expected to spread to other universities and educational institutions, creating employment opportunities in the telecommunications sector in Lebanon, helping to reduce the brain drain from the country and slowing the exodus of young people with skills in new technologies.

Another educational initiative was launched in November 2000 by Saint Joseph University (SJU) and Cisco Systems, whereby the University was designated a "Regional Academy" under the Cisco Networking Academies Programme (CNAP). This worldwide programme is a non-profit educational scheme originated by Cisco to boost the capacity of higher education institutions, providing a networking laboratory setting that closely corresponds to its real-world counterpart.

Through this initiative, SJU will be able to offer its students courses in the latest networking technologies combined with the practical experience needed to enable them to make an immediate contribution to the development of Lebanon in a knowledge-based socioeconomic context. Students can thus obtain the conceptual and practical skills required for career opportunities in the expanding ICTs. Preparation for the "Cisco Certified Networking Associate (CCNA)" diploma will also be offered by SJU, which may eventually become a training hub in networking for other institutions in Lebanon.

Similar initiatives have also been launched in other ESCWA member countries, notably Egypt, Jordan, Kuwait and the United Arab Emirates, with private industry and educational institutions forging a mutually beneficial and lasting relationship. Private firms gain by making their products well known to future professionals in various fields of high technology, while students profit from the latest knowledge in an increasingly technology-dependent economy in which they will have to work and succeed. For the colleges and universities, these initiatives represent vital technology support and resources to supplement limited funds.

B. Case Study Of A Technopole: BERYTECH[6]

The private sector in Lebanon has also embarked independently on a number of technopole and incubation projects. One such projects is BERYTECH's Technopole established by Saint Joseph University. The BERYTECH project's aims and objectives are set forth in frame 3. The project is open to universities as well as businesses interested in contributing to the realization of its aims and objectives. Along with its educational role, BERYTECH incorporates a wider national and regional vision for socioeconomic development through new technology inputs. In addition, the project's initiator is seeking to create a socioeconomic dynamic that will increase competitiveness and attract high-added-value firms to the site. A primary function of BERYTECH is to provide the necessary environment and support services to help develop added-value activities. In this connection, BERYTECH offers the following outputs:

(a) Assisting entrepreneurs in the creation of their businesses; this is done in an incubator, a nursery and a company hostel where projects are followed up until they mature into firms that are sufficiently well developed to be listed on the stock exchange;

(b) Hosting and development of existing local small firms; this can take place in a wider selection of settings, such as rented offices offering a variety of essential services at competitive rates;

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[5] Press release issued by LibanCell (www.libancell.com.lb) on the occasion of the launch of its Educational Support Programme.

[6] Based on a paper by M. Asmar and F. Rahmé entitled *BERYTECH, a Technology Park in Lebanon*, presented at the Expert Group Meeting on Capacity-building Initiatives for the Twenty-first Century, ESCWA, Beirut, 1-3 November 2000.

(c) Acting as hosts to large local or foreign companies; this can be done through real estate services providing shared or sole-occupancy rentals or full ownership of premises;

(d) Providing specialized professional training; this requires specific means and well-defined environments.

Frame 3. Aims and objectives of BERYTECH

BERYTECH aims at:

1. Helping Lebanon regain its leadership in fields where knowledge and human talent form the basis of business.
2. Encouraging entrepreneurship in high-added-value fields, especially among young graduates.
3. Bringing newly created companies and small and medium-sized technology firms together at a single location in order to create a clustering effect and enhance competitiveness.
4. Encouraging the return of Lebanese expatriates.
5. Attracting foreign investment and foreign companies.
6. Maintaining the leading role played by Lebanese universities in the region by providing educational institutions in Lebanon with a tool that promotes creative thinking and helps transform fundamental research into applied research.
7. Widening the scope of the university's educational role by helping young graduates integrate into the business world more effectively.
8. Ongoing improvements to curricula to match the needs of today's businesses.
9. Anticipating the needs of the workplace of the future.

Source: Asmar and Rahmé, *BERYTECH.*

BERYTECH's activities are currently focused on fields in which competitive advantage, expertise and human resources are generally available in Lebanon. These include:

(a) Information technology;
(b) Communications;
(c) Multimedia and Web technology;
(d) Banking and finance;
(e) Water and environment;
(f) Energy;
(g) Health sciences;
(h) Food industry;
(i) Vocational training.

C. The Lebanese Technology Incubator Project[7]

The Lebanese National Council for Scientific Research (NCSR) has plans for the establishment of a Lebanese Technology Incubator (LTI) to facilitate commercial technology applications by local start-up companies and small high-technology firms. The objective of this scheme is foster partnerships between educational and research institutions on the one hand and small high-technology industries or businesses on the other.

[7] Based on a presentation on the Lebanese Technology Incubator project by M. Hamzé and M. Mrayati at the Expert Group Meeting on Capacity-building for the Twenty-first Century, ESCWA, Beirut, 1-3 November 2000.

Direct links will be established between R and D activities in the country and manufacturing enterprises in a bid to introduce new products and services to diversify the economy, in the process creating new jobs and tapping the technical and business-related resources of Lebanese universities and research institutions, to the ultimate benefit of Lebanon's system of innovation.

Furthermore, NCSR hopes that LTI will encourage co-operation between public institutions and private businesses and enhance synergy among various sectors of the economy. By identifying technology applications suitable for commercialization, offering a structured environment that will help entrepreneurs remain focused on their short- and long-term goals and providing access to financing in the early stages of new endeavours, this incubator scheme will greatly increase small firms' chances of success and lead to a more versatile and dynamic economy.

LTI will encompass industrial fields that reflect its strengths and will concentrate on technologies that will serve those fields, adding new ones as the need arises. The most important manufacturing industries in Lebanon at present are:

(a) Agro-food industries, with estimated yearly production amounting to US$ 1.4 billion;

(b) Textile and garments, with production in the amount of nearly US$ 796 million per year;

(c) Metal fabricating and machinery, with estimated yearly production amounting to US$ 715 million.

On the service side, tourism and banking are sectors in which Lebanon excelled in the recent past; new technologies, particularly information and communications technologies (ICTs) would be likely to contribute added value, greater competitiveness and productivity to these sectors as well.

Other technologies that have been identified as suited to Lebanon's needs include biotechnology and new materials. The former would help modernize the agro-food industry, while the latter would rejuvenate the textile, construction and light engineering industries and enhance their competitiveness and productivity.

IV. ACADEMIC NETWORKS - A MAJOR COMPONENT OF S&T STRATEGY IN LEBANON

Over the past two decades, academic communities all over the world, whether higher education institutions, national research institutes, centers of excellence, or industrial research centers strived towards establishing computer networks that link them together, given 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 RENATER in France, that enhance the communications capabilities among national academic communities and help advancing 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.

Five years ago efforts have been deployed by the UNESCO Cairo Office in the Arab region to build pilot academic networks linking universities and research centers at the national level, following a model that was widespread in European academic communities. Academic networks were planned for Lebanon, Palestinian Territories, 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. The establishment of similar academic networks in countries of the region should lead to the creation of a wider regional academic network that will facilitate exchanges between Arab universities and more collaboration between researchers. It constitutes a step in the right direction towards

the networked knowledge-based economy. Frame 4 presents general information on one academic network, the Lebanese University Network (LUN), how it was planned and its long and short-term objectives.

Frame 4. The Lebanese University Network

At the request of the Lebanese Government and due to the fact that the Lebanese University[8] (LU) lacked any networking infrastructure while other private universities had already some networking facilities in their campuses, the Lebanese project focused on establishing a Lebanese University Network (LUN) to connect about 20 campuses and sites, mostly in the Beirut area, forming an intranet, with gateways to the Internet. Funding was mainly provided by UNDP and OMSAR, through its administrative reform project, with some cost sharing by UNESCO and the Lebanese University.

The long-term objective of the Lebanese academic network is to assist in achieving sustainable human resource development by helping the country accelerate development of Information and Communication Technology (ICT) facilities, skills, and use. The short-term objective is the creation of essential infrastructure facilities at the Lebanese University to use and adapt ICT for upgrading their programmes of teaching, research and administration through:

- Improving services at the University;
- Making LU more accessible through accessing its services electronically, anywhere and anytime;
- Improving the quality, timeliness, and accessibility of information in order to support decision-making processes at all levels;
- Improving efficiency and effectiveness at the operational level;
- Re-envision the academic services in order to move the organization toward the future;
- Achieve sustainable human resource development through the use of Informatics and Communications facilities;
- Allow all LU human resources (faculty, technical and administrative staff, students) to develop and to share knowledge in order to enhance their performance appraisal and their skills.

Source: Al-Abbas, F. et al, "Academic networks in Syria and Lebanon: Objectives, structure and collaboration potential", in Proceedings of the First Syrian-Lebanese Symposium on Information & Communication Technology Development, 25-29 April 2000.

V. SCIENCE AND TECHNOLOGY INDICATORS IN LEBANON

A. RESEARCH AND DEVELOPMENT INDICATORS

The capacity to undertake innovation activities is directly related to national R and D activity in Lebanon. The general tendency in R and D assessment has been to emphasize quantitative input indicators over output indicators. The complexity of estimating R and D output has incited wider use of indicators such as expenditure on R and D, number of R and D personnel, and the number of R and D projects in a particular area[9]. 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 5 presents indicators providing information on a country's support for, and performance in R and D.

[8] The Lebanese University is the official national institution responsible for Higher Education in Lebanon. Scattered around the country are 48 sites, 3,000 full-time faculty members, 2,000 part-time faculty members, 2,000 staff members and a student body counting 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 US$ 14,000 exceeding by far the average GNP of the country).

[9] 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.

Frame 5. Indicators providing information on a country's support for, and performance in R and D

- **Business Enterprise R and D Expenditure (BERD):** Accounts for contributions to R and D activity made by firms, organizations and institutes that primarily produce goods and services[10] for sale to the general public, as well as the non-profit private institutions that service them. Contributions to R and D by public sector enterprises are also included within this category.
- **Government R and D Expenditure (GOVERD):** Incorporates R and D expenditure by agencies, offices, and other entities that offer public goods and services[11], 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 and D Expenditure (higher education RD):** Accounts for R and D expenditure by higher education institutions, such as universities and colleges, irrespective of their source of funding, 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 and D Expenditure (PNPERD):** Includes expenditure by non-profit institutions that serve the public sector, as well as those by individual donors to R and D activity.
- **Extra-national contributions:** Refers to contributions by organizations and individuals resident abroad[12]. 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/SDPD/2003/5)

It may be possible to develop more intricate indicator systems and conduct more detailed analyses with regards to R and D contributions by the business and governmental sectors in Lebanon. Obviously more recent data would need to be available especially those related to the type of research expenditure, and area of scientific or technological activity.

From a quantitative point of view, R and D output can be measured through an assessment of the knowledge embodied in published scientific discoveries and technological innovations, as well as from sources of information that detail published research reports and patents. However, the creation of knowledge that stems from R and D activities is more difficult to measure.

B. 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 public research institutes. They address both the quantity and the quality of such activity. In common with other indicators, they are significant only in a comparative sense.

The use of bibliometric data is based on the premise that the ultimate objective of scientific effort is knowledge production and that this is reflected in relevant literature. This is one of the basic weaknesses of using bibliometrics as an indicator. Despite their extensive use for evaluating scientific output, bibliometric indicators possess some additional shortcomings:

[10] Excluding higher education

[11] Excluding higher education

[12] With the exception of the cars, ships, airplanes and space satellites that are operated by domestic organizations and the experimental locations of these organizations.

- Different scientific fields publish and cite prior work differently. Variations are also present between countries;
- Language biases may arise due to working with selected journals and periodicals. This is especially true in the developing countries, particularly those in which the working language of instruction and scientific communication is not English. Naturally the Arab countries fall in this category;
- Certain valuable scientific output that has become part of the "obvious" may no longer be cited.
- Extended periods of time often elapse between reporting a given result and adequate recognition of its value;
- Principal periodicals refer only to productive experimental or laboratory work, leaving out innovations in important including computation or software development.

Bibliometric indicators usually 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, which could be accomplished by the following techniques:

- Relative specialization index: indicates the country's share of global publications in specific scientific fields relative to its share across all fields;
- Co-authorship: determines the link between different geographical regions by the association of several authors on the same publication;
- Scientific productivity: measures the productivity of individual organizations;
- Citation-based indicators: quantifies the citations or references made to an article from other articles over a certain period of time.

C. 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.

Limitations from resorting to patents as a measure of STI output include the following:

- Variations in patent systems across countries;
- Discrepancies as a result of differing tendencies to patent between sectors and organizations;
- Difficulties in assigning patents to a specific country or geographical location as some firms tend to patent centrally, i.e. applying from headquarters irrespective of the geographical location of the invention;
- Most patents never reach commercialisation, and as such their true contribution to competitiveness and productivity is not made.
- Some worthwhile inventions, primarily of cultural nature, but also including software items and certain biotechnology/genomic products such as new forms of life, are not protected with patents.

Based on data collected through patent offices, it is possible to extract several variables pointing to the extent and level of patenting activity:

- Summarized description of the invention;
- Various patent counts according to country, industry or technological field, time period, assignee type[13];
- Geographical distribution of assignees;
- Percentage shares of patent renewals;
- Number and type of contested patents.

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[13] Could be an individual, a company, university, etc.

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 of companies due to the impact of technology. Patents have been extensively studied in witnessing company economic growth;
- Determinants of technological advance relating to the production/import of new technology;
- Spillovers/knowledge flows implying the extent of technological exchange and knowledge accumulation;
- Technology foresight inferring the evolution of technological advance, and the impact of certain technologies on productivity.

D. Higher Education Indicators

A set of widely used S and T input indicators are utilized in Lebanon to evaluate the performance of higher education institutions and their contribution to the accumulation of skilled human resources and intellectual capital. Gender segregated statistics are available but not necessarily up-to-date. Data collected for these indicators should (and generally are) encompass the field of specialization, degree or diploma, year of graduation, geographic location of the educational institution, and nationality of the graduate. Factors such as enrolment in the different levels of the national system of higher education are also available.

Both input and output elements should be used to analyse 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 considering a broad perspective of life-long learning, rather than restrict focus to the current labour market.

Some input indicators that may be useful to assess higher education in Lebanon comprise: expenditure on higher education, the number of students enrolled in the various stages and areas of specialization, and the ratio of students to professorial and assistant staff. Other indicators, such as spending on higher education in relation to gross domestic product and per student are also used. Moreover, the amount and type of equipment, science facilities, and number of computers available in institutions are important.

On the other hand, 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.

VI. INNOVATION INDICATORS IN LEBANON

The development and diffusion of new technologies in Lebanon play a central role in securing improved productivity and competitiveness. Indeed, the global economy is being reshaped by new information technologies and by radical technological changes in a number of other disciplines in science and technology. 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.

Success in refining the analysis of innovation is essential in improving understanding of the link between technological change and economic performance. More importantly, in the case of Lebanon, such success will help in formulating strategies for the collection and analysis of information on innovation flows and the promotion of national capacity building in innovation.

A. Technological Product and Process (TPP) Innovation

In general, introducing TPP innovation involves activities on a wide front; aimed at securing inputs of scientific, technological, organisational, financial and commercial origins. It is often that 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.

A given entity, firm or institution, may engage in successful innovation leading to the creation and commercialisation of a new or improved product or process. However, innovation may be aborted due to difficulties encountered during various stages of the process of introducing innovative inputs in the product or process targeted. TPP innovations may also be aborted due to changes in market conditions and also due to regulatory or legislative changes, either national or international.

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.

B. 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.

The main problem facing this indicator is that data collected on high technology is often too general for reliable analysis. Using the data in conjunction with other data on R and D would perhaps help attain a more comprehensive view. Even so, it is not possible to clearly determine high technology content in a product. Moreover, the lack of standards by which to measure technological intensity, leads firms to classify products with similar technology content differently. It is with a view to resolving this difficulty that OECD and Eurostat have produced a list of products stipulating their technology content.

In its 2001 Human Development Report, the United Nations Development Program classifies exports as "low", "medium" or "high" technology. According to these definitions, a majority of ESCWA member countries do not export any high-technology content. The two exceptions are Egypt and Oman where high-technology exports account for a mere 2 per cent of their total goods exports, each. Medium-technology exports, such as various types of manufacturing equipment, are only slightly more common in ESCWA member countries. In the same line, Table 3 presents indicators related STI transfer. Other STI indicators can be found in Annex I.

TABLE 3: INDICATORS RELATED TO STI TRANSFER

CONTRACTS	
Indicator	**Definition**
Number of contracts dedicated to consultancies and acquisition to know-how across sectors and countries	The number of consultancy contracts concluded in the following sectors: Agriculture and Fishing, Defence, Industry, Infrastructure, Services, Tourism and Transport.
Value of contracts dedicated to consultancies and acquisition to know-how across sectors and countries	The value of consultancy contracts concluded in the following sectors: Agriculture and Fishing, Defence, Industry, Infrastructure, Services, Tourism and Transport.
Number of industrial contracts concluded by sector	The number of industrial contracts concluded in the following fields: cement and glass, metallurgical, oil and gas, petrochemicals, pharmaceutical, power, waste management, water and others.
Number of infrastructure contracts concluded by sector	The number of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications, and water.
Value of industrial contracts concluded by sector	The value of industrial contracts concluded in the following fields: cement and glass, metallurgical, oil and gas, petrochemicals, pharmaceutical, power, waste management, water and others.
Value of infrastructure contracts concluded by sector	The value of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications, and water.

Source: Economic and Social Commission for Western Asia (ESCWA). New Indicators for Science, Technology, and Innovation in the Knowledge-Based Society, 2003. (E/ESCWA/SDPD/2003/5)

VII. CONCLUSIONS

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 it, 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:

(a) lack of institutional arrangements dedicated to STI monitoring and evaluation; and
(b) the limited degree of agreement among institutions on common definitions for some of the main entities addressed in STI performance evaluation exercises.

There is a pressing need to set up national STI observatories in Lebanon dedicated to monitoring STI capabilities. These observatories should be an integral part of the design of a national STI policy and the implementation of strategies. Additionally, it would be essential to form modalities that promote demand for information produced by these observatories. In particular, it will be of the utmost importance to set up national STI policy research units, capable of analysing national observatory outputs for the benefit of policy and decision-making. Designs aimed at implementing national STI strategies should include pilot activities aimed towards these ends. It is suggested that these observatories and consequent steps be hosted by NCSRL.

Monitoring the evolution of STI capabilities may certainly be facilitated by developments in ICTs. 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 regard to entities engaged in monitoring and licensing industrial enterprises related to issues of technology transfer and utilization activities, product and process innovations, etc., with minimal expenditure of costs and manpower efforts. 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. Many aspects of implementing such indicators will require a great deal of research activity, which reinforces the necessity for linking national STI observatories to policy research facilities.

In summary, greater efforts need to be exerted in Lebanon to collect and analyse 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.

ANNEX I. SELECTED SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS

TABLE II.1. INDICATORS RELATED TO STI CREATION

RESEARCH AND DEVELOPMENT	
Indicator	**Definition**
Gross Domestic Expenditure on R&D (GERD)	Gross Domestic Expenditure on Research and Development (GERD) is total intramural expenditure on R&D performed on the national territory during a given period.
GERD as a percentage of GDP	The Gross Domestic Expenditure on R&D expressed as a percentage of the Gross Domestic Product.
GERD per capita	The Gross Domestic Expenditure on R&D divided by the total population.
Percentage of GERD allocated to different sectors	The percentage of Gross Domestic Expenditure on R&D in the following different sectors (Business enterprise, Government, Private non-profit, Higher education, Abroad).
Percentage of GERD financed by organizations abroad	The percentage of Gross Domestic Expenditure on R and D financed by organization abroad out of the total GERD. The abroad section includes: • All institutions and individuals located outside the political borders of a country, except vehicles, ships, aircraft and space satellites operated by domestic entities and testing grounds acquired by such entities. • All international organizations (except business enterprises), including facilities and operations within the country's borders.
Full-Time Equivalent (FTE) researchers per capita	Full-time equivalent staff is a true measure of the volume of R&D. One FTE may be thought of as one person-year. Personnel should be measured as the number of person-years on R&D over the same period as the expenditure series.
Number of R and D support personnel	Other R and D supporting staff include skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects.
Number of national institutions involved in R&D	All National institutions including Universities and other organizations involved in R and D. According to the Frascati Manual, research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D must be distinguished from a wide range of related activities with a scientific and technological basis which should be excluded when measuring R&D.– Education and training.– Other related scientific and technological activities.– Other industrial activities.– Administration and other supporting activities.
National/regional prizes dedicated as incentives to researchers and inventors	The number of all national and regional prizes dedicated as incentives to researchers and inventors.
Number of registered patents	A patent is defined by the Oslo Manual as a legal property right over an invention, which is granted by national patent offices. Patent statistics are increasingly used in various ways by technology students as indicators of the output of invention activities.
Publications in refereed journals	A refereed journal has a structured reviewing system in which at least two reviewers, excluding in-house editors, evaluate each unsolicited manuscript and advise the editor as to acceptance or rejection.
Co-authorship and other forms of STI cooperation with developed countries.	Co-authored publications involve authors from at least two different countries and are defined by research papers in which there are addresses of at least two authors in different countries. Note that the method of counting co-authored publications involves including all countries participating in the publication.

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/...)

TABLE II.2: INDICATORS RELATED TO STI DISSEMINATION

EDUCATION AND LITERACY	
Indicator	**Definition**
Literacy Rate (percentage)	Percentage of persons aged 15 and over who can read and write a short, simple statement on their everyday life.
Growth in Literacy Rate	Percentage of increase of literacy rate over several years.
Primary School Enrolment	Ratio of children of all ages enrolled in primary school to the country's population of school-age children (ages 6-11).
Secondary School Enrolment	Ratio of children of all ages enrolled in secondary school to the country's population of school-age children (12-17).
Secondary Technical Enrolment Average	Average over several years of the ratio of pupils preparing directly for a trade or occupation other than teaching, to total secondary school enrolment.
HIGHER EDUCATION	
Indicator	**Definition**
Number of Universities and other Institutions of Higher Education	The total number of national Universities and Institutions of Higher Education.
Tertiary School Enrolment	Ratio of the number of pupils enrolled in all post-secondary schools and institutions by the population in the 18-24 age group.
Number of students enrolled in STI fields (Bachelors, Masters, PhD)	Students currently enrolled in the natural and applied sciences, including medicine, as a percent of total enrolled students.
Number of graduates in STI fields (Bachelors, Masters, PhD)	Tertiary graduates in the natural and applied sciences, including medicine, as a percent of total graduates.
Higher education expenditure	Capital Expenditure on education is expenditure for assets that last longer than one year. It includes expenditure for construction, renovation and major repairs of buildings and the purchase of heavy equipment or vehicles. The current Expenditure on Education is the expenditure for goods and services consumed within the current year and which would need to be renewed if there were a need for prolongation the following year. It includes expenditure on: staff salaries and benefits; contracted or purchased services; other resources including books and teaching materials; and other current expenditure such as furniture and equipment.
Higher education expenditure as a percentage of GDP	Total expenditure on higher education expressed as a percentage of the Gross Domestic Product.
Higher education expenditure per capita	The Higher Education Expenditure divided by the total population.
Number of S&T colleges in universities	The number of Science and Technology colleges that provide studies in the following fields: engineering, natural sciences, mathematics and computers.
Number of H&SS colleges in universities	The number of Humanities and Social Sciences colleges that offer studies in the following fields: social and behavioural sciences, journalism and information, business and administration, and law.
Distribution of S&T colleges in universities by area	The ratio of the different areas of Science and Technology colleges (Basic Sciences, Computer, Engineering, Medicine, Pharmacy, Dentistry, Nursing, Para Medicine, Agriculture, Veterinary Science, Others) in universities to the total number of Science and Technology colleges.

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/...)

TABLE II.3: INDICATORS RELATED TO STI TRANSFER

CONTRACTS	
Indicator	**Definition**
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Number of infrastructure contracts concluded by sector	The number of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications, and water.
Value of industrial contracts concluded by sector	The value of industrial contracts concluded in the following fields: cement and glass, metallurgical, oil and gas, petrochemicals, pharmaceutical, power, waste management, water and others.
Value of infrastructure contracts concluded by sector	The value of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications, and water.

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/...)

TABLE II.4: INDICATORS RELATED TO STI UTILISATION

EMPLOYMENT[14]	
Indicator	**Definition**
Employment in industry (% of total employment)	The industry sector includes mining and quarrying (including oil production), manufacturing, construction, electricity, gas, and water.
Employment in services (% of total employment)	Services include wholesale and retail trade and restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services.
Employment in industry, female (% of total employment)	The number of females employed in industry expressed as a percentage of the total number of people employed in industry.
Employment in services, male (% of total employment)	The number of males employed in services expressed as a percentage of the total number of people employed in industry.
TECHNOLOGY TRANSFER	
Indicator	**Definition**
Exports of high technology	High-technology exports are products with high R&D intensity. They include high-technology products such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.
Exports of medium technology	Automotive products, manufacturing equipment (such as agricultural, textile and food processing machinery), some forms of steel (tubes and primary forms) and chemical products such as polymers, fertilizers and explosives.
Exports of low technology	Low technology exports include textiles, paper, glassware, and basic steel and iron products (such as sheets, wires and un-worked casting).

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/...)

[14] The concept of employment generally refers to people above a certain age who worked, or who held a job, during a reference period. Employment data include both full-time and part-time workers.

Staff Members Initials	2005				Staff member/WM			Remarks
	1st Q	2nd Q	3rd Q	4th Q	HK	AAR	ZZ1	
Sustainable Development and Productivity Division								
1. Servicing of intergovernmental and expert bodies								
1.c. Ad hoc expert groups								
Access to environmental information for public participation in the ESCWA region		June			1	3	3	
2. Other substantive activities								
2.a. Recurrent publications								
Review of productivity and sustainable development activities, No. 4					1	1	1	
2.b. Non-recurrent publications								
2.c. Technical material (including databases and software):								
2.d. Seminars organised by the Secretariat for outside users under specific mandates								
Development of sustainable development indicators and country profiles in selected sectors (agriculture, energy, environment, industry, technology and water)	Continuous (2004-05)				0.5	2.5	*2.5*	
3. Technical cooperation								
3.a Field projects	**N/A in 2004**							
4. Multi-Disciplinary Activities								
Substantive Servicing of Intergovernmental meeting of CAMRE & JCEDAR (Follow-up on implementation of WSSD outcomes)	Continuous (2004-05)				2.5	5.5	5.5	Umbrella Project
Total Planned WM per Staff Member					**5**	**12**	**12**	