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EDITORIAL STATEMENT

This is the first in a series of Reviews that the Technology Section of the ESCWA Sectoral Issues and Policies Division plans to produce on a regular basis in the coming years.[1]

The primary objective of the present Review is to report on activities undertaken in the ESCWA member countries to enhance capabilities in science and technology. Information is also presented on relevant activities implemented, or planned for future implementation, by the Technology Section.

National capabilities in science and technology (S and T) are increasingly being recognized as key determinants of economic growth and international competitiveness. The prevalent view of tomorrow's world is dominated by vanishing trade barriers, dwindling natural resources, greater concern for the environment, the emergence of international quality regimes, and strict regulations governing intellectual property rights. Few would contest the fact that the importance of S and T capabilities will be further reinforced within this perspective.

In the ESCWA member countries, several steps have been taken over the past few decades, particularly with regard to establishing university faculties,[2] research and development centres,[3] and calibration and standards facilities. Nevertheless, with the twentieth anniversary of the convening of the United Nations Conference on Science and Technology for Development, rapidly approaching, there is a growing realization that a good deal remains to be done. Thus, apart from the task of reforming systems of higher education—work that must be undertaken continually by all countries both developed and developing—more needs to be done to formulate and revise S and T policies as well as shore up extra resources for R and D activity. Further work is also needed in setting up standards facilities and quality assurance bodies. Above all, more work is needed in linking up national S and T systems with production and services facilities both at home and abroad. In all of the above, acquiring viable information infrastructures is of paramount importance. The contents of the present Review were selected with special attention to these issues. In particular, the present Review focuses attention on the following:

- Moves towards formulating national S and T policies and strategies in the ESCWA member countries;
- Assessment and promotion of research and development (R and D) activity in the ESCWA member countries;
- Technology transfer activity as indicated by contracts for the installation of production and services facilities in the ESCWA member countries.

Excerpts from a selection of papers produced by staff of the Technology Section as well as by authors participating in meetings on the above issues have also been included in this issue of the Review.

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[1] The Review of science and technology in ESCWA member countries is part of the Technology Section's official programme of work during the current biennium, 1998-1999, and it is hoped that the Review will also be included in the Section's programme of work for the next biennium, 2000-2001.

[2] Information on this point is reported by a recent publication by ESCWA and UNESCO. See the outline provided in this Review (p. 33).

[3] See the information presented in this Review on the recently published ESCWA Directory of Research and Development Institutes in the ESCWA Member Countries (p. 32).

CONTENTS

ABBREVIATIONS AND ACRONYMS

AIDMO	Arab Industrial Development and Mining Organization
ALDOC	Arab League Document Centre
ALECSO	Arab League Educational, Cultural and Scientific Organization
AOCR	Arabic optical character recognition
ASMO	Arab Standardization und Metrology Organization
ASRT	Academy and Scientific Research and Technology (Egypt)
ASTINET	Arab Science and Technology Information Network
BMBF	Bundesministerium für Bildung und Forschung (German Federal Ministry for Development and Research)
CAD	computer-assisted design
CAE	computer-assisted education
CAM	computer-assisted manufacturing
CASL	Central Analysis and Service Laboratories (Egypt)
CNI	Centre National d'Informatique
CIMMYT	International Centre for Wheat and Maize Improvement
COMSATS	Commission on Science and Technology for Sustainable Development in the South
DH	doubled-haploid
DNA	deoxyribonucleic acid
EC	European Community
ECMA	European Computer Manufacturing Association
ESCA	electron scattering chemical analysis
EST	Environmentally sound technology
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	foreign direct investment
FTE	full-time equivalent
GATT	General Agreement on Tariffs and Trade
GCC	Gulf Cooperation Council
GDP	gross domestic product
GIS	Geographic Information System
GNP	gross net product
GTZ	German Agency for Technical Cooperation
IAEA	International Atomic Energy Agency
ICARDA	International Centre for Agricultural Research in Dry Areas
IFSTAD	Islamic Foundation for Science, Technology and Development
ILO	International Labour Organization
INIS	International Nuclear Information System (database)
ISO	International Organization for Standardization
ISRA	Institute of Study and Research on Arabization (Morocco)
IT	Information technology
JICA	Japan International Cooperation Agency
KISR	Kuwait Institute for Scientific Research
KFUPM	King Fahd University of Petroleum and Minerals (Saudi Arabia)
LARN	Lebanese Academic and Research Network
LE	Egyptian pound
LMW	low molecular weight
MERC	Middle East Regional Cooperation Program
MIS	Management information systems
NARS	National Agricultural Research Systems (Syrian Arab Republic)
NCC	National Computer Centre (Iraq)
NCSR	National Council for Scientific Research (Lebanon)
NGO	non-governmental organization
NIDOC	National Information and Documentation Centre (Egypt)
NRC	National Research Centre (Egypt)
OAPEC	Organization of Arab Petroleum Exporting Countries

ABBREVIATIONS AND ACRONYMS *(continued)*

OECD	Organisation for Economic Cooperation and Development
PCR	Polymerase chain reaction
PTC	plant tissue culture
PVC	polyvinyl chloride
QTL	Quantitive trait loci
R and D	Research and development
RAPD	Randomly amplified polymorphic DNA
R, D and E	Research, development and engineering
RFLP	Restriction fragment length polymorphism
ROSTAS	Regional Office for Science and Technology in the Arab States (UNESCO Cairo Office)
RITSEC	Regional Information Technology and Software Engineering Centre (Egypt)
RSS	Royal Scientific Society (Jordan)
RTD	Research and technological development
S and T	science and technology
SCRs	Scientific Research Centres (Lebanon)
SME	small and medium enterprise
SRls	Saudi Arabian riyals
SSRC	Scientific Studies and Research Centre (Syrian Arab Republic)
STC	Science and Technology Cooperation Programme (Egypt)
TIES	Technical Information Exchange System
TRIPS	trade-related aspects of intellectual property rights
TWAS	Third World Academy of Sciences
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNU/INTECH	United Nations University/Institute for New Technologies
USAID	United States Agency for International Development
WANA	West Asia and North Africa
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

PART I*

* This part of the Review comprises contributions on technology development issues of concern to the ESCWA member countries.

Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA member countries

The Technology Section in the ESCWA Sectoral Issues and Policies Division organized in December 1997 an Expert Group Meeting that was entirely devoted to the assessment and promotion of R and D in the ESCWA member countries. The Meeting was designed to build upon results achieved by previous ESCWA activities carried out with the aim of enhancing technological capabilities in the member countries.

The principal objectives of this particular Meeting were:

- To evaluate developments taking place within R and D systems in the ESCWA member countries in response to global and regional changes;

- To chart possible approaches to the promotion of R and D capabilities, with an emphasis on networking and cooperation at the national and regional levels.

The meeting was designed to include plenary sessions as well as parallel working group sessions. Box 1 presents an overview of the organization of the Meeting.

The plenary sessions dealt with issues of general concern to the assessment and promotion of R and D in the ESCWA member countries. The working group sessions focused on R and D in the specific areas listed in box 1 below that were deemed especially important for sustainable development efforts in the ESCWA member countries. Assessment of existing R and D capabilities in these areas addressed the role of Governments and end-user communities in supporting R and D activities. Issues concerning the impact of policies, resource levels and institutional structures on linkages with end-user communities were singled out for special attention.

The following section provides a summary overview of the plenary presentations and subsequent discussions. It is followed by another section that is devoted to a brief review of presentations made in the working group sessions. Selected contributions to the Meeting are presented in part II of the Review. A comprehensive list of the presentations at the Meeting is also provided at the end of part II.

Box 1. Organization of the Expert Group Meeting

The Meeting's plenary sessions

- *Assessment of R and D in the ESCWA member countries;*
- *Coordination and cooperation in R and D in the ESCWA member countries.*

The Meeting's Working Group sessions:

Working Group I

- *R and D in water resources and water treatment;*
- *R and D in applications of selected agricultural biotechnologies.*

Working Group II

- *R and D in selected industrial activities;*
- *R and D in pollution treatment and waste recycling.*

Working Group III

- *Women's R and D opportunities in selected ESCWA member countries.*

Presentations and discussions at the plenary sessions

The plenary sessions of the Meeting gave participants a regional overview, followed by national perspectives, of R and D capabilities in the ESCWA member countries. Both qualitative and quantitative indicators of R and D activity were addressed. The contributions and ensuing discussions addressed the need to develop systems of indicators capable of responding to the characteristics of prevailing socio-economic settings in the ESCWA member countries, as well as the stage of development of the S and T systems in these countries. The need to develop new indicators of R and D performance as well as to collect and analyse information to characterize R and D output and demand for R and D services was also considered.

R and D in the ESCWA member countries

R and D activity in the ESCWA member countries takes place within policy, legislative and regulatory frameworks lacking in maturity and flexibility. Most of the ESCWA member countries will thus need to formulate and implement comprehensive S and T policies. Only a limited number of ESCWA member countries have embarked—or are planning to embark—on such endeavours, and where such policies do exist, attempts at linking them to national development planning require further attention to achieve success.

Research in the ESCWA member countries is carried out mainly in institutes of higher education. The trend towards establishing R and D centres dedicated to particular industrial sectors is relatively recent. Egypt and Saudi Arabia are in a leading position among ESCWA member countries in this respect.

In addition, it is only recently that planning and marketing functions have been taken into account by a small number of ESCWA R and D institutions. Planning units are often assigned follow-up and bookkeeping work rather than strategic responsibilities. They are generally somewhat removed from the centre of the decision-making process, particularly when long-term and strategic planning are concerned. In general, it was found that regulatory and procedural obstacles delay responses to end-user requirements and slow down the transfer of results from the laboratory bench to the pilot plant and into production and commercialization.

Quantitative and structural inadequacies characterize R and D manpower resources in all ESCWA member countries. It was also noted that a lack of managerial experience was a common problem.

Furthermore, R and D activity in the ESCWA member countries suffered severe financial resource constraints (see table 1 and figures I and II below). This has led at least some R and D institutions in some ESCWA member countries to devote increasing manpower resources to technical, standardization and quality assurance services. This seems to degrade their performance in areas identified as priorities in national and institutional plans. Shortages were also observed in the accessibility of "information resources". Only a few R and D organizations were found to have adequate Internet linkages.

A considerable proportion of R and D activity was thought to fall within traditional fields of science and technology. In particular, R and D activity in agriculture and the health sciences appears to constitute a major chunk of overall R and D activity. A small number of institutions, however, reported increasing preoccupation with R and D aimed at the acquisition and dissemination of novel information and telecommunications technologies, genetic engineering, new materials technologies and modern energy conversion systems.

Despite the above, generally disquieting, state of affairs, the following encouraging trends have been noted:

(a) Recent moves have been taken by several countries in the region to formulate and implement national S and T policies;

(b) Growth has been noted in research reporting, in particular in the cases of Egypt and Saudi Arabia;

(c) Attempts at regional and subregional cooperation are being made in areas that affect future R and D capabilities, notably the UNESCO programme for training R and D managers;

TABLE 1. R AND D EXPENDITURE IN THE ARAB STATES IN 1996

State	R and D expenditure (thousands of US dollars)	Population (millions)	GDP per capita income (US dollars)	Labour force (thousands)
United Arab Emirates	10 886	2.4	17 958	955
Iraq	27 573	20.3	3 892	4 782
Lebanon	7 453	3.1	4 323	999
Bahrain	3 736	0.6	8 667	230
Qatar	5 461	0.6	12 667	251
Oman	10 755	2.2	6 500	922
Syrian Arab Republic	24 184	14.6	1 199	3 678
Saudi Arabia	196 094	18.5	7 000	5 400
Yemen	10 297	15.8	310	4 040
Kuwait	67 113	1.7	16 882	527
Jordan	20 615	4.4	1 614	1 197
Egypt	227 499	61	1 139	17 261

Source: Subhi Qasem, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (ESCWA and ROSTAS, 1998).

(d) There have also been moves towards closer collaboration between R and D institutions and end-users in several ESCWA member countries, in particular in Egypt, but also in Saudi Arabia;

(e) Departments and laboratories charged with training, as well as R and D activities within areas of new technologies, have been created in a number of ESCWA member countries;

(f) R and D institutions, notably in Jordan and Egypt, are engaged in efforts to market their services and reach out for possible new "clients".

There is a need to build upon and accelerate such trends.

Coordination, cooperation and networking among R and D institutions in the ESCWA member countries were still at an embryonic stage of development. As a result, available expertise is underutilized. This was thought to have led to diminished abilities to make full use of international initiatives involving R and D cooperation.

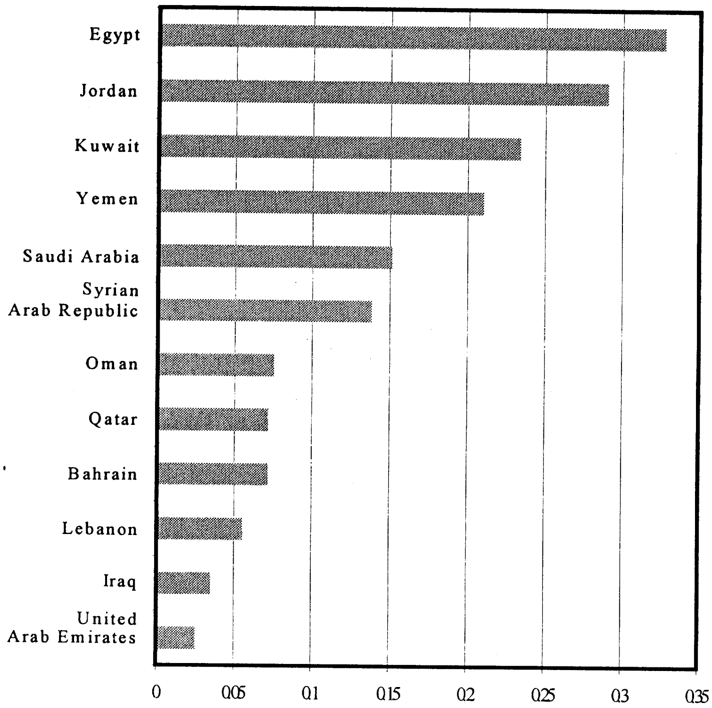


Figure I.

Percentage ratio of R and D expenditure to GDP (1996)

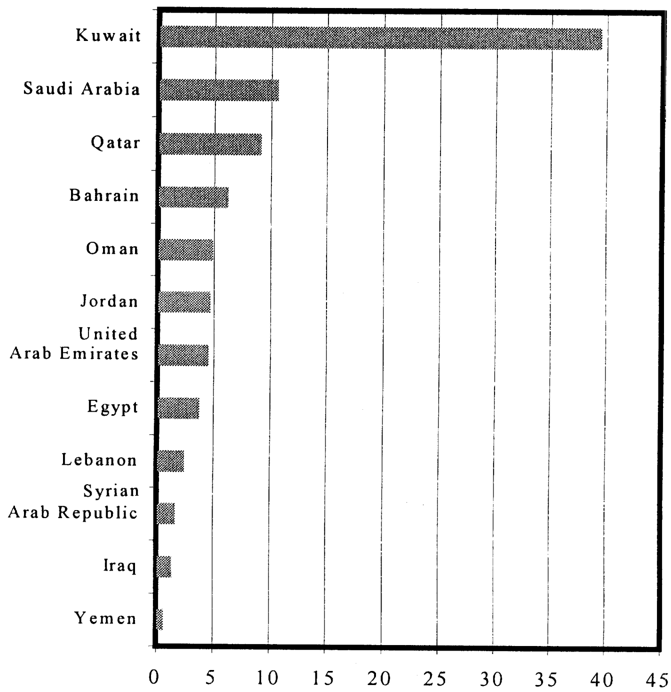


Figure II.

R and D expenditure per capita (in $US) in 1996

Source: Subhi Qasem, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (ESCWA and ROSTAS, 1998).

It was evident that no single ESCWA member country possessed all of the human and material resources necessary to undertake the full range of activities in the numerous priority areas addressed by the concerned institutions. Through a pooling of resources, however, these institutions could have access to a wider range of capabilities.

Presentations and discussions in the working group sessions

The following paragraphs provide a summary of the main issues addressed by the presentations and ensuing discussions during the working group sessions.

R and D in water resources and water treatment

The papers presented within the Working Group on R and D in Water Resources and Water Treatment addressed both national and regional aspects of R and D assessment and promotion with regard to water resources, water use and water conservation.

Water resources the world over are rapidly becoming ever more scarce and precious. Water shortages, particularly in some ESCWA member countries, have acquired crisis proportions. Yet numerous industrial and agricultural activities in these countries still rely on outdated and wasteful technologies.

More effective water resource utilization, better wastewater treatment and cheaper desalination methodologies may be effectively acquired, further adapted and more widely disseminated in the region through cooperative efforts involving end-users, investors, legislative authorities, and standardization bodies as well as R and D institutions. In particular, more effective networking and coordination at the policy and planning levels are essential to ensure a long-lasting impact. Regional networks involving specialized R and D institutions could foster cooperation, with the emphasis on water management issues, technology assessment and technology transfer.

Several obstacles need to be addressed at the national level. In particular, there is need to address the following:

(a) The scarcity and inadequate quality of information about resources, consumption patterns and quality issues;

(b) The duplication of R and D efforts at the national and even the institutional levels;

(b) The duplication of R and D efforts at the national and even the institutional levels;

(c) The lack of coordination with concerned authorities, particularly when future plans by these authorities are concerned.

One important issue is the changing role of Governments with regard to the future development of water resources. Thus, as profit-making enterprises acquire wider responsibilities in the operation and dissemination of water technologies, greater emphasis will have to be placed on environmental and quality standards than hitherto, with government departments and consumer organizations assuming regulatory and quality control functions.

It was considered essential by participants in the Working Group that Governments evolve and coordinate integrated R and D pollution control programmes emphasizing the issues listed in box 2. R and D related to these issues bring about the adaptation of environmentally sound technologies (ESTs). Specific areas of long-term research activity were also identified as requiring focused attention. One such area was the study of the toxicological effects, under local conditions, of pollutants generated by industry and agriculture. This was considered by participants in the Working Group as essential if more effective guidelines were to be developed for waste disposal and the introduction of appropriate ESTs. Other areas of long-term priority in R and D on water resources and water use in the region include the development and adaptation of water desalination technologies and the conservation of water resources through improved utilization schemes in both rural and urban settings. Possibilities exist in these, as well as in many other areas, for R and D cooperation between institutions in the ESCWA member countries. In particular, co-operation involving industrial concerns will result in creating business opportunities emphasizing water conservation, the manufacture of equipment for monitoring water quality and water treatment, and improvement of environmental protection.

Box 2. R and D areas in water utilization, conservation, treatment and recycling

- Water resource assessment, resource management and conservation;
- Sewage stream treatment and reuse;
- Industrial wastewater treatment and recycling;
- Rationalization in the use of irrigation water through the upgrading of existing technologies and current management practices;
- Waste reduction and recycling to ensure rational pollution prevention rather than mere transfer of pollution from one part of the environment to another.

R and D in applications of selected agricultural biotechnologies

The viewpoints presented in the papers and discussions in the Working Group are highlighted below.

The 1980s witnessed giant developments in the biological sciences, culminating in the capacity for genetic transformation of life-forms and the imparting of characteristics not previously possessed by animal species. Genetically modified unicellular entities as well as higher animal species, capable of mass-producing rare chemicals, pharmaceuticals and food ingredients, may also be possible in the not too distant future. However, concern for the environment as well as the quality of agricultural produce is at the centre of efforts to develop and introduce biotechnologies in agricultural applications.

The ESCWA member countries are overall importers of agricultural produce and food commodities. In addition, the agricultural sector is awarded priority in government policies in many ESCWA member countries, yet growth in agricultural production is limited by inadequate water supplies and poor soil fertility in many parts of the region.

Biotechnologies are thus expected to assume increasing importance in the years to come for the countries of the region. Particular attention has been awarded in the ESCWA member countries to plant tissue culture (PTC) techniques as a route to developing and propagating improved crop varieties. Several institutions in the ESCWA member countries have acquired acceptable capabilities in these somewhat traditional biotechnologies. Emphasis in this area will, therefore, have to be placed on disseminating development capabilities and enhancing the ability of concerned institutions to commercialize their results on the basis of fully validated PTC protocols.

R and D activity in more advanced agricultural biotechnologies is still largely confined to international organizations operating in the region, such as the International Centre for Agricultural Research in Dry Areas (ICARDA). This Centre utilizes non-radioactive DNA technology to establish marker-assisted selection systems with a view to enhancing stress tolerance and in order to improve the efficiency of germ-plasm collection, management and utilization. The work performed in this area and in other fields by ICARDA and associated organizations provides valuable information on the modalities of international cooperation and the manner in which field testing and linkages to end-user populations are established.

R and D cooperation is considered more important in the field of advanced biotechnologies, which are generally capital-intensive owing to the need for highly trained manpower and an elaborate infrastructure.

Box 3. R and D in applications of selected agricultural biotechnologies

- Fermentation processes for agro-food and industrial applications;
- New bioreactor processes and improvement of the performance of established processes;
- Genetic engineering for applications in plant and animal production;
- Biotechnologies for integrated pest management;
- Plant cell and tissue culture in sustainable agricultural production with emphasis on arid and saline agriculture.

Other areas of agricultural biotechnologies deserving of greater interest include biofortified farming systems. These systems are expected to play a greater role in sustainable agricultural development, relying mainly upon biofertilizers and biopesticides, often to replace or reinforce the effects of purely chemical nutritive supplements and pesticides. Applications of biotechnologies in other areas, such as the production of pharmaceuticals and food products, have tended to receive less attention in the ESCWA member countries. The food-processing industry nevertheless constitutes an area in which region-specific biotechnologies may be developed with considerable benefits. Box 3 includes a list of areas considered as potential candidates for R and D cooperation in the ESCWA member countries.

R and D in selected industrial activities

Papers and discussions in the Working Group emphasized the need for future industrial development in the ESCWA member countries to proceed with the backing of indigenous R and D activities that emphasize product quality and environmental compatibility. Local and national government departments, as well as regional groupings, still played a crucial role in support of industrial R and D initiatives. Initiatives launched and sponsored by Governments, with private sector support—in Europe, for example—focused on areas affecting competitiveness, the environment, health and work safety. While not precluding international cooperation with outside sources of technology, it was considered increasingly important for industrial and R and D institutions in the ESCWA member countries to achieve more effective linkages at the national and regional levels. In particular, more effective networking among national R and D institutions and with quality and standardization bodies was essential. Reforms at the policy, managerial and operational levels were also essential for effective co-operation.

The R and D requirements of small and medium enterprises (SMEs) were considered of particular importance in the coming few years as SMEs would struggle to ward off the impact of open trade and competition from more efficient and better organized producers abroad.

Enhanced quality, health aspects and environmental compatibility were expected to feature prominently in any agenda aimed at promoting SMEs. The achievement of those goals would require close collaboration between R and D institutions and federations of industrial enterprises. Such cooperation would involve setting priorities, securing funding and even the manufacture of new products and the introduction of novel processes for use by SMEs.

An evaluation of previous efforts in industrial R and D in the ESCWA member countries indicated particular weakness in the ability to move the results of R and D from the laboratory and pilot scale stages to the production line. Success in this domain was considered essential to the continued viability of a wide range of industries in the next few years.

Participants in the Working Group emphasized the need for concerned governmental and non-governmental organizations (NGOs) to address the issues listed in box 4. The absence or weakness of national legislation and enforcement measures aimed at protecting the region's fragile ecologies from rapid industrial development constituted a major source of concern, particularly at a time when calls for regional and global environmental quality agreements were becoming increasingly more vehement. When concluded, such agreements would impose serious constraints on international trade in a variety of areas. Hence, the importance of developing the capability to generate technological inputs aimed at improving the environmental profiles of products and processes developed and utilized in the ESCWA member countries.

Box 4. Promoting industrial R and D in the ESCWA member countries

- Formulate industrial technology strategies and R and D plans in a manner that ensures close conformity with national industrial development plans;
- Focus on a limited set of technological fields of direct relevance to priority industrial activities of importance to the country in question;

Box 4. *(continued)*

- Ensure full participation of the end-users of industrial R and D output in all stages of project development;
- Enhance the capabilities and involvement of chambers of industry and commerce as well as national and regional associations of producers, in identifying and responding to the R and D needs of industrial enterprises, with emphasis on SMEs;
- Accelerate institution-building and promote resource allocations to infrastructural facilities, with emphasis on standardization and quality assurance capabilities.

R and D in pollution treatment and waste recycling

Papers presented in the Working Group reviewed R and D activities on industrial pollution treatment and recycling. The general conclusion was that further support for R and D in that domain was urgently needed if it was to deliver results and generate, adapt and disseminate viable indigenous technology inputs. Establishing stronger links between R and D communities and bodies concerned with industrial development and the environment, both governmental and otherwise, was considered an issue deserving of urgent attention.

Participants in the Working Group session concurred that:

(a) Higher resource levels must be allocated to the development and adaptation of mature environmentally sound technologies;

(b) R and D institutions and production organizations should be encouraged to intensify joint activities in the field of industrial pollution treatment and waste recycling;

(c) Financial grants and tax exemptions should be widely used, among other means, to facilitate such activities.

Box 5. Promoting R and D on industrial pollution and waste recycling in the ESCWA member countries

Past experience in R and D activity on industrial pollution and waste recycling in the ESCWA member countries indicates the need:

- To design and implement more economical waste collection, sorting, transportation and treatment schemes;
- To improve the quality and usability of recycled wastes;
- To develop standards for industrial waste treatment and recycling processes, with emphasis on areas in which such wastes are recycled for use in food and agricultural production.

The ESCWA member countries could benefit greatly from individual experiences in specific R and D activities aimed at pollution treatment and waste recycling. It was crucial that R and D on industrial pollution be carried out in a manner that ensured close attention to sector- and even segment-specific issues without losing sight of the wider socio-economic perspective.

Information technologies

Papers presented in the Working Group highlighted steps taken by several institutions of higher education as well as research centres in the ESCWA member countries to establish R and D capabilities in selected areas of information technology, including software development for administrative and financial applications, database management systems, simple automation and control applications, Arabic language processing, and multimedia uses. In general, little R and D on information technologies is carried out by the universities and, with a few exceptions, none is undertaken by the private sector in most ESCWA member countries. In addition, collaboration among local information technology institutions remains weak.

Areas in which experience was thought to be particularly lacking were packaging and marketing of software products.

The fact that R and D capabilities in information technologies appear to be at substantially different levels of development in the ESCWA member countries suggests the possibility for fruitful collaboration between these countries in future.

The areas presented in box 6 were considered in need of particular support by Governments, R and D institutions and businesses.

Cooperative ventures in these and other areas were expected to yield considerable benefits. In order for such ventures to succeed, efforts must be made to develop common standards and to induce greater commitment to such standards. Success in networking R and D in these areas should go some way towards the development, adoption and dissemination of such standards. A particular area in which such networking should produce useful results is Arabization of software and hardware systems.

Women's R and D opportunities in selected ESCWA member countries

This Working Group was intended to provide a forum for the exchange of views and experiences among women scientists working in R and D institutions in the ESCWA region. The principal objective of presentations and discussions in the

Working Group was to highlight the need for new approaches to national and regional R and D policies and strategies with a view to ensuring a more effective role for women researchers as active contributors to sustainable development.

Box 6. R and D areas in information technologies highlighted by the participants in Working Group II

- The indigenous development of software for specific local administrative and management requirements in the public and private sectors and the Arabization of selected software packages;
- Development of Arabized computer-assisted education (CAE) software for various levels;
- Development and adaptation of computer-assisted design (CAD) and computer-assisted manufacturing (CAM) systems with emphasis on industrial control and environmental protection;
- Enhancement of training and technology adaptation/integration capabilities in multimedia and expert systems with emphasis on the needs of, and participation by, small and medium enterprises.

Country papers highlighting women's R and D contributions in Egypt, Jordan, Iraq, Lebanon and the Syrian Arab Republic were presented.

It was apparent that information on women in R and D in the ESCWA member countries was scarce. Further, preliminary studies indicated that science and technology-related occupations available to women were limited. However, reports on female employment have shown that there are sizeable communities of women scientists and engineers in some countries,[1] which justifies studies aimed at enhancing their contribution to R and D policy design and management.

The Working Group's discussions attempted to assess women's performance and their local contributions in R and D, as well as the sensitivity of science and technology policies to women's issues. The issue of gender equity in science and technology, as well as the gender nature of decision-making within R and D institutions was examined to the extent permitted by available data.

Observations on difficulties faced by women scientists embarking on professional careers in R and D were highlighted. It was noted that information on women's activities and programmes in R and D was still scarce, and that disaggregated data were not available at the national and institutional levels.

Issues identified as areas for further study by the Working Group are listed in box 7.

Box 7. Areas for further study highlighted by participants in the Working Group on Women's R and D Opportunities in Selected ESCWA Member Countries

- The differential impact of technological changes on the lives of women and men in the region;
- The potential of the many qualified female scientists and engineers;
- Future opportunities for women scientists and engineers;
- The status of female participation in specific R and D areas.

Conclusions and recommendations of the Meeting

The main conclusions and recommendations of the Meeting are listed below.

CONCLUSIONS

Recent global and regional developments with wide-ranging implications for international competitiveness, as well as access to and utilization of intellectual property, particularly with regard to innovative products and processes, will create an entirely new climate for the conduct of R and D. Furthermore, the emergence of regional groupings is already exerting a considerable impact on international and interregional trade through a number of modalities, including product and environmental quality regimes. Adjusting to the conditions imposed by such developments and responding to their implications for the production and services sectors in the ESCWA member countries will depend more than ever before upon the ability to generate local technological inputs through endogenous R and D activities.

Adjustments will have to be made at the levels of policy, resource allocation, management and linkages to end-user communities, if R and D activity in the ESCWA member countries is to contribute positively to the quest of these countries for sustainable development objectives. A common view was that many of the challenges faced by the ESCWA member countries in the economic, social and environmental domains would only yield to concerted action by R and D communities, concerned government departments and business enterprises. R and D coordination and networking at the regional levels was also expected to play an important part in enhancing the contributions of R and D to sustainable development efforts.

Attempts at improving conditions for R and D institutions, in terms of funding and improved

[1] For example, in Egypt, Iraq, Jordan, Lebanon and the Syrian Arab Republic.

legislative and regulatory frameworks, appear to be in the pipeline in several ESCWA member countries. Notable successes have already been achieved in some cases. Building on such successes will require further effort at the policy, legislative, regulatory, organizational and managerial levels as well as improvements in available means of access to information on new technologies in a number of areas and the assessment of their environmental and social implications.

RECOMMENDATIONS

The recommendations drawn from the discussions and papers presented at the Expert Group Meeting were reviewed by a panel of experts at the conclusion of the Meeting. They were thought to be of immediate and long-term relevance to a wide range of S and T institutions. The intention was that the recommendations would be taken into account by the concerned institutions and organizations at the national and regional levels in their planning of future exercises.

Science and technology policies and support for R and D activity

There is still much to be done with regard to formulating and refining science and technology policies and measures that guarantee effective support for R and D activities.

Support provided by science and technology policies for R and D activities should be more closely integrated with overall development policies, in the industrial, agricultural and service sectors.

R and D activity in areas characterized by low and long-term economic returns

Involvement by governmental and non-governmental bodies in the promotion of R and D must be strengthened, particularly in areas where investment in R and D activity is not likely to result in speedy returns and in areas where the end-users are still far from being sufficiently well-equipped to fund specific R and D efforts.

Further resources—human, financial and institutional—should be made available for R and D in the above areas. These resources must come from Governments, federations of private and public enterprises and professional associations. Modalities for priority setting and funding in such areas should be worked out in cooperation with the above-mentioned bodies, with as much interaction and coordination as possible at the national and regional levels.

R and D needs of small and medium enterprises

R and D needs of SMEs will require greater attention than they have hitherto received. In this respect, NGOs, in particular producers' federations and professional, craft and vocational associations, must become more closely involved in priority setting and R and D funding.

Organizational structures, management practices and the "marketing orientation"

Organizational structures will have to be revised with the aim of acquiring greater efficiency and to allow greater interdisciplinary and interinstitutional interaction. In certain cases, R and D institutions need to become directly integrated with specific production and service entities.

Further improvements are needed in the main management functions of planning, programming, budgeting and evaluation in R and D institutions.

Strategic planning must become a continuous exercise and a means of updating institutional capabilities.

The adoption of more forthright "marketing" approaches by R and D institutions was strongly recommended in certain areas. R and D institutions in the ESCWA member countries also have to develop the ability to identify new markets and areas of activity. They also need to optimize their "product" portfolios, organizational structures and resource allocations accordingly.

At the same time, concern with the end-users' immediate as well as future needs must be cultivated by R and D management. A longer-term view, affording a wider perspective of R and D activities and encompassing environmental as well as socio-economic issues, must be taken. Managerial instruments that allow effective planning at different levels—including national, institutional, and sectoral, and within several time-frames—are also urgently needed.

Standardization bodies and technical service facilities

It was agreed that higher resource levels must be allocated in a number of ESCWA member countries to establish and strengthen standards and quality assurance bodies as well as institutions responsible for providing technical services to various sectors. Effective linkages must also be fostered between standards and quality assurance bodies and R and D institutions.

The information resource

Improving the flow of information in areas crucial to the success of R and D is urgently needed. In particular, it is essential to establish national and regional databases on R and D in ESCWA member countries and to facilitate the dissemination of information collected in such databases through modern means provided by novel computer and telecommunications technologies.

Monitoring the capabilities of R and D systems

More attention must be paid to studies concerning both qualitative and quantitative aspects of the output of R and D in the region. Cooperation between national and regional organizations is essential to developing more accurate and informative indicators for the evaluation of R and D outputs.

Women's R and D opportunities

The Meeting emphasised the need for the following:

(a) Setting up a comprehensive database focusing on information critical to the enhancement of the role of women in scientific research;

(b) Gender-sensitive career guidance at the early stages in the process of career development for girls and young women;

(c) A plan of action for further integrating women scientists and technologists in R and D activity in the ESCWA member countries;

(d) A network of women scientists and engineers.

Concerned national and regional agencies have been called upon to award greater attention to developing and monitoring gender-specific R and D indicators and to making the scientific community in the ESCWA member countries aware of progress achieved in the participation of women in R and D activities.

R and D coordination, cooperation and networking

The concept of setting up R and D networks with the aim of encouraging more intensive interaction between institutions and individuals was discussed at some length during the Meeting. There was unanimous agreement regarding the need to adopt more collaborative approaches, both within each ESCWA member country and among institutions in the various ESCWA member countries. Such collaborative efforts should be conducted on the basis of the following:

(a) Clear concepts and mutually defined objectives;

(b) Detailed plans covering all aspects of a project's life-cycle and the widest possible scope of its implications.

It was felt that starting with simple collaborative projects that were a common priority among the member countries was a key element in the success of R and D collaboration. Cooperation in training of R and D personnel was also considered an exceedingly important starting point.

Experience proves that cooperative R and D ventures can be more readily designed, managed and implemented than can long-term coordination of R and D activity. It was agreed, however, that coordination of R and D efforts in priority area would be improved by making information about national and institutional R and D priorities and plans more readily available.

Specialized R and D networks, encompassing as many ESCWA member country institutions as possible, were deemed essential as a means for dissemination of information about:

(a) R and D plans;
(b) R and D results;
(c) Available expertise.

R and D networks would allow speedy and cost-effective development in crucial areas, principally through information-sharing and minimizing duplication. The view was expressed that networking should also increase opportunities to utilize R and D results through improved visibility and linkages to end-users. Some of the participants emphasized the value of such networks as vehicles for the exchange of information concerning the assessment of new technologies.

However, it was felt that R and D networks should be established on the basis of actual needs and must be related to the member countries' development priorities. Participants proposed the areas listed in box 8 below as suitable for networking with the aim of information exchange in preparation for more intensive R and D cooperation and coordination. Box 9 lists observations made by the participants concerning mechanisms for setting up and running these networks.

Stronger linkages must be formed both among R and D institutions as well as between R and D institutions and their end-user communities.

Box 8. Areas considered as suitable for R and D networking in the ESCWA member countries

- Advanced materials;
- Arabization in information technology;
- Construction and construction materials;
- Integration of information technology in manufacturing;
- Irrigation systems and water quality;
- Multimedia systems;
- R and D management training;
- Remote sensing for agricultural and ecological applications;
- Renewable energy technologies;
- Selected biotechnologies for agricultural and industrial applications;
- Solid waste treatment;
- Technology assessment and technology policy;
- Water conservation;
- Water desalination;
- Water treatment and recycling;
- Women in R and D.

New methods to bring the R and D and business communities in closer and more constant contact must be actively investigated and implemented.

R and D institutions and other concerned institutions, including SMEs and their federations/associations, in the ESCWA region need to become more closely involved as partners in international R and D programmes, such as those organized by the European Union, including ESPRIT, EUREKA, AVICENNE and INCO-DC. The participation of these institutions in such programmes will lend valuable support to local R and D and help national institutions to acquire expertise in the various facets of modern R and D management. Establishing specialized R and D networks in the ESCWA member countries will have the dual effect of facilitating membership in such programmes as well as result in strengthening intraregional R and D linkages.

Agreement was reached on the need to set up specialized R and D networks and on the desirability of starting with simple arrangements and the adoption of a gradualist approach in their development.

It was agreed that the responsibilities taken up by the focal points of the proposed networks had to be kept to a minimum. In later stages, further resources should be made available from national, regional and international organizations to support gradual expansion of the networks' activities. Such expansion would need to include the operation of specialized training programmes as well as schemes aimed at the exchange of R and D professionals and cooperation in conducting well-defined R and D activities.

Other issues on which agreement was reached concerned the need for the following:

(a) To involve, whenever possible, governmental and non-governmental bodies, including federations of producers and professional associations, in R and D networking arrangement;

(b) To view R and D networks as a prelude to long-term strategic alliances in well-defined areas of mutual concern for participating institutions;

(c) To seek and analyse fully the resources available to concerned regional and international organizations in promoting regional and international coordination and cooperation in R and D.

Box 9. Collected observations on networking mechanisms

A primary task of R and D networks is to present their members with information about R and D institutions and their activities. The recently developed ESCWA database of R and D institutions (ESCWA-DRI), as well as other specialized databases, could form the basis for contacts and exchange of information.

The use of the Internet will naturally aid in the dissemination of information about R and D institutions in the region and their activities. The Internet should be utilized whenever and wherever available to create linkages and information exchange facilities.

A gradualist approach is to be followed in the development of the networks. Task forces need to be set up within and among concerned institutions to help in the initiation of networking activity. These task forces should cooperate on a voluntary basis to undertake preliminary studies before launching a proposed R and D network. Among other things, such studies might consider objectives, potential participants and costs. Efforts should also be made to involve members of end-user communities in the proposed networks.

The experiences of other international and regional organizations in coordination, cooperation, networking and the exchange of technical information should be taken into account to the fullest degree possible. Examples include the Technical Information Exchange System (TIES) of UNIDO (United Nations Industrial Development Organization) and AIDMO (Arab Industrial Development and Mining Organization).

Contracts reported during the period 1992-1998 involving the transfer of technology

The Middle East Economic Digest (MEED) compiles, on a monthly basis, a list of the major contracts awarded in the Middle East. On the basis of this information, the ESCWA Technology Section conducted a survey of the contracts concluded between mainly public sector organizations in the ESCWA member countries and a variety of organizations during the period 1992-September 1998. The survey revealed regional development and demand trends in vital sectors such as industry and transport as well as infrastructure building.

Table 1 shows the distribution of all contracts reported as concluded by ESCWA member countries during the period 1992-September 1998. It should be noted that since not all the contracts listed in MEED included an evaluation of monetary values, the real total value of all contracts concluded within this period under survey should surpass the reported total. The "real" total value of all contracts may well exceed 120 per cent of that reported. It should also be emphasized that defence contracts are sometimes excluded from the reports published by MEED. As can be seen from table 1, the largest number of contracts was concluded in Saudi Arabia (746 contracts) with a total value exceeding US$ 37 billion, followed by the United Arab Emirates (515 contracts) and Egypt (353 contracts) and representing values of approximately $26 billion and $15 billion respectively.

TABLE 1. DISTRIBUTION OF ALL CONTRACTS REPORTED AS CONCLUDED BY ESCWA MEMBERS DURING THE PERIOD 1992-September 1998
(Millions of US dollars)

Country/area	No. of contracts	Total value of contracts
Bahrain	152	4 024.57
Egypt	353	15 148.49
Gaza/West Bank	46	212.81
Iraq	9	31.50
Jordan	229	2 880.00
Kuwait	267	8 875.14
Lebanon	104	4 153.93
Oman	256	4 679.76
Qatar	209	8 326.15
Saudi Arabia	746	37 541.87
Syrian Arab Republic	100	4 159.81
United Arab Emirates	515	25 758.34
Yemen	99	1 505.28
Total	3 085	117 315.83

Table 2 shows the distribution of the above-mentioned contracts according to economic sector. Clearly, ESCWA members tend to focus on industrial (982 projects) and infrastructure-related projects (910 projects). It can also be deduced, from the information provided in the table, what areas are being neglected in addition to the areas included in technology transfer in the ESCWA members. For example, projects related to environmental pollution or environmental amelioration do not appear in the list in table 2.

Focus on 1998 contracts

According to MEED, 294 contracts were awarded in the ESCWA member countries in the period from January to September 1998. Table 3 shows the distribution of these contracts according to sector.

Of the 92 industrial projects, those related to the oil and gas industry (28 projects) accounted for nearly US$ 2.7 billion, or 35 per cent of the total contract value of industrial projects. In the services sector, the telecommunications field accounted for the highest number and value of contracts (20 contracts, with a value exceeding US$ 1.5 billion).

TABLE 2. SECTOR DISTRIBUTION OF CONTRACTS CONCLUDED BY THE ESCWA MEMBER COUNTRIES DURING 1992-September 1998
(Millions of US dollars)

Sector	No. of contracts	Sector total
Agriculture/fishing	42	468.27
Defence	120	11 686.34
Economic restructuring	2	37
Industry	982	45 672.92
Infrastructure	910	29 551.80
Services	488	12 057.67
Tourism	137	1 726.65
Transport	404	16 115.18
Total	3 085	117 315.83

For example, a contract for the installation of GSM (Global System for Mobile communications) lines and the modernization of telephone switching systems in Saudi Arabia was awarded for a value of US$ 810 million. Two other contracts, involving fibre optic and satellite connectivity, were also signed.

TABLE 3. DISTRIBUTION OF ALL CONTRACTS REPORTED AS CONCLUDED BY ESCWA MEMBER COUNTRIES DURING THE PERIOD JANUARY-SEPTEMBER 1998
(Millions of US dollars)

Sector	No. of projects	Value
Agriculture/fishing	1	40.00
Defence	4	3 382.40
Industry	92	7 565.00
Infrastructure	59	1 529.30
Services	67	2 741.51

TABLE 3. *(continued)*

Sector	No. of projects	Value
Tourism	26	233.90
Transport	45	3 193.43

In the Syrian Arab Republic, six telecommunications contracts were signed; four of these contracts have a stated total value of US$ 320 million. The contracts involve the modernization and expansion of the telephone network through fibre optic and microwave links, and the installation of new switching systems.

In Egypt, five telecommunications contracts were signed with a value exceeding US$ 392 million. The projects deal with the upgrade of the GSM and switching telephone systems, as well as satellite television broadcasting. Similar projects are also being undertaken in the United Arab Emirates (4 projects), Qatar (3 projects), Bahrain (2 projects), Kuwait (1 project), Lebanon (1 project), and Oman (1 project).

New plants or equipment

In the area of chemicals and petrochemicals, 10 contracts were signed in Saudi Arabia for a total value exceeding US$ 1 billion (some contract values were not stated). Four of those contracts involve the construction of new plants while the rest involve the expansion of the plant or upgrade of equipment. In Qatar, three contracts were signed for a total value of US$ 443.5 million. The largest of these contracts involves the construction of a new vinyl plant, and has a value of US$ 430 million.

The metallurgy sector was also prominent, especially in Egypt. Three contracts involve the supply of equipment for iron and steel factories in Egypt, for a total value exceeding US$ 267 million. A contract for building a new iron plant was signed in Qatar, and a US$ 725 million expansion project for an aluminium plant was initiated in the United Arab Emirates.

Worth noting also are three contracts for new cement plants (value exceeding US$ 151 million) and one contract for a new fertilizer plant in Egypt (for US$ 253 million).

World Conference on Science for the Twenty-first Century: A New Commitment

The United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU), in cooperation with other partners, are holding the World Conference on Science for the Twenty-first Century: A New Commitment in Budapest from 26 June to 1 July 1999.

The objective of the Conference is to characterize the current state of sciences and their social impact, and to discuss the prospects for the advancement of sciences.

Areas of emphasis will be:

- Challenges facing sciences;
- Science as a problem-solving tool;
- Interfaces between science and society;
- Public understanding of science;
- Role of Governments, policy makers, and the scientific community.

The outcome of the Conference will be embodied in two documents: A Declaration on Science and the Use of Scientific Knowledge, and a Science Agenda, intended as a framework for action. The draft declaration is reproduced on page 18.

The Internet and information technology in the ESCWA region: a brief overview

With the number of Internet users around the world reaching more than 140 million, the Arab countries are catching up with the world trend at a fast rate. The information technology sector in the Middle East, for example, is growing at approximately three times the world growth rate. The following is a brief characterization of the status of Internet usage in selected Arab countries.

In the United Arab Emirates, Internet services were first introduced in 1995. Since then, the number of Internet subscriptions increased from 2,500 in 1995 to 27,000 in 1997, and is currently nearing 55,000. The service is provided through one company, Etisalat, either through phone lines or an integrated service digital network (ISDN). The cost of the service differs, depending on the type of subscription and transmission speed required, and is around US $ 1.7/hour for individual accounts.

In Egypt, the annual expenditure on information technologies is reported to have exceeded US$ 400 million, and around 1,200 small, medium and large enterprises have been set up to cater for this sector. Internet services were commercially introduced to the public in early 1998, and the current number of Internet users is approximately 100,000. It is expected that Internet use will grow rapidly as subscription fees are lowered further. There are 40 service providers, all from the private sector.

In Saudi Arabia, Internet access is expected to become available early in 1999. A total of 164 companies applied to provide Internet services; 75 of them were expected to obtain licences by the end of 1998. These companies are to be connected to a single main network that will provide the connection to the Internet, and the specifications for this network are being prepared by King Abdulaziz City for Science and Technology (KACST). The number of Internet users for the first year is expected to exceed 100,000.

In Lebanon, the American University of Beirut first provided Internet services to its staff through a satellite link in 1993; these services became commercially available in 1996. Twelve service providers are currently in operation, all privately owned, and the number of Internet users is approximately 40,000. The average subscription fee is US$1.5/hour.

Internet services were also introduced in Jordan in 1996, and currently, 10 companies provide Internet services to around 30,000 users. The number of users is expected to increase, however, as subscription fees are lowered further.

In the Syrian Arab Republic, government efforts aimed at providing Syrians with appropriate computer training will certainly help to boost Internet usage, which is currently limited to colleges, ministries and other institutions. Internet service is provided through one company only, and the subscription fee is comparatively high, set at US$ 2.5/hour.

In most of the Arab countries, concerns are raised regarding the widespread use of the Internet in relation to public morals, piracy, invasion of privacy, and computer viruses. Efforts are made to deny public access to sites that offend religious and moral values. In this regard, most countries are implementing safety systems such as firewalls/proxy servers. As to presence on the Web, an increasing number of institutions and companies are creating their own sites, which are usually hosted at the service providers' servers. As a minimum, these sites provide information on the institution concerned and the possibility to make contact through e-mail. Less frequently, the sites also provide database search and download functionality. Electronic commerce (e-commerce) is still at an embryonic stage, and in this regard, Egypt has embarked on a project of hosting sites for around 250 commercial institutions on the Web, in the hope of increasing exports. Some of the technical barriers to e-commerce will be eliminated with improvements in the telecom infrastructure and the provision of means for secure electronic transactions. (See the paper on "R and D in information technology in the Syrian Arab Republic" in part II of this Review).

Source: Asharq Al-Awsat, issues 3, 5, 6, 8 and 17 October 1998; and *Al-Hayat*, 8 September 1998.

There is growing awareness of the importance of capacity-building in S and T in responding to the consequences of globalization, liberalization of trade, and intellectual property rights. As a result, several ESCWA member countries are taking serious steps to formulate and implement S and T policies. These policies have generally targeted the promotion of R and D activities and the dissemination of specific technologies, principally through government efforts. It should be noted that the importance of S and T policies to efforts aimed at promoting R and D activities may not be confined to those parts of the policies that explicitly address support for R and D. It is important to consider both implied and explicit approaches to technology transfer and the creation of auxiliary S and T capabilities.

The following is a brief outline of S and T efforts in selected ESCWA member countries. Further information is available in the ESCWA study titled "Assessment of Research and Development in Selected ESCWA Member Countries: Local Technological Inputs" (see page 32 of this Review).

S and T policy in Egypt

A science and technology policy document for Egypt was completed in May 1996. The policy sets the year 2017 as the target date for Egypt to reach the level of newly industrialized countries. Main issues addressed in the document include the following:

- Institutional reform of the science and technology structure;
- Resources for the science and technology system, including financial and human resources;
- Enhancing returns from contributions made by R and D institutions;
- Innovation and competitiveness as the basis for an export strategy;
- Technology transfer (through training, importation of machinery, and encouraging cooperation and coordination between planning bodies and research centres);
- High technology and "big science" projects (such as genetic engineering, electronics, informatics, new materials and pharmaceuticals);
- International cooperation;
- Complementarity with the fabric of Egyptian life;
- Harmonization of the legislative environment.

The document also deals with the social implications of technology development, and acknowledges the need to change the legislative setting so as to arrive at conditions that are conducive to S and T development.

S and T policy in Jordan

A national science and technology policy for Jordan was formulated in 1995, with the collaboration of the Higher Council for Science and Technology (HCST). Jordan's policy addresses the following elements:

- Information;
- Human resources;
- Research and development (with special emphasis on topics such as mineral resources, water, energy, and the environment);
- Technology acquisition.

The HCST has also conducted studies on the national scientific and technological requirements and potential, with the aim of formulating more specialized policies.

S and T policy in Lebanon

The Lebanese science and technology policy was formulated by the National Council for Scientific Research (NCSR) in 1994. It is aimed at achieving an optimal utilization of national resources, especially those of governmental scientific institutions. Work programmes for the implementation of this policy have also been defined, including the distribution of funds and the coordination/orientation of scientific research, especially in applied and basic sciences. Points addressed in the policy are:

- General objectives;
- Components of Lebanon's scientific policy;
- Implementing Lebanon's science policy;
- Tasks for the Government of Lebanon;
- General and financial considerations;
- Researchers and their training;
- Research climate;
- Areas for investment in research;

- Research projects' plan;
- Means for policy implementation.

S and T policy in Saudi Arabia

In Saudi Arabia, serious and consolidated efforts are being made to formulate a "comprehensive national plan" for science and technology covering the years 2000-2020. A number of specialists from the King Abdulaziz City for Science and Technology and other concerned institutions have been charged with conducting surveys and "futures" studies in specific sectors, such as energy, health, the environment, electronics, biotechnology, education and management science. The entire exercise is expected to be completed before the beginning of the seventh five-year national plan. This will facilitate the coordinating of the comprehensive S and T plan with the consecutive five-year national development plans. In this regard, a special committee has been charged with the task of formulating five-year S and T plans to be implemented concurrently with the national development plans.

S and T policy in the Syrian Arab Republic

In the Syrian Arab Republic, concrete efforts to formulate a science and technology policy were initiated in 1992. The plan exists in the form of directives, which were compiled by representatives of ministries, mainly those of Industry and Higher Education, and universities, research institutions, the main public industrial enterprises and other concerned bodies. Several committees of specialists were formed to supervise the implementation of these directives, which basically relate to the following research topics:

- Medical and related research;
- Agricultural and veterinary research;
- Engineering research;
- Basic science research.

S and T policy in Kuwait

At its inception the Kuwait Institute for Scientific Research (KISR) was assigned duties that closely relate to the formulation of S and T policy in Kuwait. Senior KISR officials represented the country at the United Nations Conference on Science and Technology for Development, held in Vienna in 1979. The national document presented at the conference declared Kuwait's intention to increase R and D spending.

KISR was involved in producing a series of five-year R and D plans and several policy studies concerning the development of Kuwait's S and T capabilities in the late 1980s. A recent attempt, concluded in June 1998, was confined to R and D policies, and has recently been produced by KISR professionals for consideration by the Kuwaiti authorities.

A still more recent, and more comprehensive, effort was aimed at drawing up a full-fledged S and T policy and is currently in the initial planning stages. Both KISR and Kuwait's Ministry of Planning will be involved. Technical assistance is being sought by KISR from concerned international organizations such as ESCWA and a project document on the subject is currently being prepared.

Role of ESCWA

ESCWA is providing technical assistance to its member countries, namely Saudi Arabia and Kuwait, in S and T policy formulation. In addition, the ESCWA Technology Section was organizing an expert group meeting, scheduled to be held in March 1999, which aimed at training policy-making bodies and high-level decision makers in the formulation and implementation of S and T policies. (For more information on this meeting, see page 29 of this Review.)

DRAFT DECLARATION ON SCIENCE AND THE USE OF SCIENTIFIC KNOWLEDGE
(Preliminary version)
Preamble

We have come to recognize that we all live on the same planet and are all part of the biosphere, and that the future of humankind is intrinsically linked to the preservation of the global life-support systems and to the survival of all forms of life. All nations of the world are called upon to acknowledge the urgency of using knowledge from the natural and social sciences to address human needs without indulging in its misuse. Science should be at the service of humanity as a whole, and should contribute to providing a deeper understanding of nature and society, a better quality of life for everyone and a healthy and productive environment for present and future generations.

Steadily improving scientific knowledge of the origin, functions and evolution of the universe and of life provides humankind with a rational view which profoundly influences the conduct of human affairs. Scientific knowledge has yielded applications that have been of great benefit to humankind. Life expectancy has strikingly increased, cures are available - or foreseen - for many diseases, and health care has improved dramatically. Agricultural output has risen to meet population needs, at least in global terms. Technological developments and the exploitation of energy sources have created the capacity for freeing humankind from the most arduous labour. The new communication and information technologies have brought unprecedented opportunities for interaction between peoples and individuals.

However, all these benefits are unequally distributed, and this has widened the gap between industrialized and developing countries. In addition, the application of scientific advances has also led to environmental degradation and has been a source of social imbalance or exclusion. Scientific and technological progress has also made possible the construction of sophisticated weapons, including atomic, biological and chemical ones, having the potential to destroy life on a mass scale or even put at risk the entire planet. Today, there is an opportunity for fewer resources to be allocated to the development and manufacture of new weapons and for military research facilities to be at least partially converted to civilian use. The United Nations has proclaimed the Year 2000 as the International Year for the Culture of Peace as a step towards a lasting peace between and within countries; science and the scientific community can and should play an essential role in this process.

Today, while unprecedented advances in science are foreseen, there is a need for a vigorous democratic debate on the ethical, cultural, environmental and economical aspects of the use of scientific knowledge. Enhancing the role of science for a more equitable, prosperous and sustainable world requires a long-term commitment of all stakeholders: Governments and Parliaments, scientists and engineers, industry, the media, international organizations and society at large. Greater interdisciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with crucial social, economic, cultural, environmental and health issues. It will also require that public trust and support for science be strengthened through a new social contract. This calls, in particular, for a commitment on the part of the social and natural scientists to analyse the impact of the natural sciences on society.

We, participants in the World Conference on Science for the Twenty-first Century: A New Commitment, assembled in Budapest, Hungary, from 26 June to 1 July 1999 under the aegis of the United Nations Educational, Scientific and Cultural Organization and the International Council for Science,

Recognizing that science is a powerful intellectual resource for understanding natural and societal phenomena, and that the role of science promises to be greater in the future, also because of the growing complexity of the interrelationship between society and nature;

Also recognizing that scientific information is indispensable today for decision-makers and for society at large;

Considering that scientific research yields inestimable returns in terms of sustainable development and improvement in the quality of life;

Convinced that science and its applications are a major factor in socio-economic development and that the future of humankind will be more dependent on the production, distribution and use of knowledge than ever before;

Acknowledging that scientific issues are largely of a universal nature, know no borders and require international recognition, assessment, coordination and cooperation;

Taking into account the recommendations of major conferences organized by the United Nations system and the meetings associated with the World Conference on Science;

Stressing that access to scientific knowledge is part of the right to education and the right to information belonging to all people, and that science education is essential for human development and for creating endogenous scientific capacity;

Recalling that scientific research and the use of scientific knowledge should respect human rights and the dignity of human beings, and recalling further the relevant articles in the Universal Declaration of Human Rights;

Stressing the need to practice and apply science in line with appropriate ethical requirements;

Emphasizing that the use of scientific knowledge should respect biological diversity, as well as the life-supporting systems of our plant;

Appreciating the importance of traditional and local knowledge and the need to safeguard and make better use of it;

Considering that a new social contract between science and society is necessary to cope with such pressing contemporary problems as poverty, environmental degradation, public health and food security;

Underlining the need for a strong commitment of political, economic and social partners to science, as well as an equally strong commitment of scientists to the well-being of society;

DRAFT DECLARATION ON SCIENCE AND THE USE OF SCIENTIFIC KNOWLEDGE *(continued)*

Proclaim the following:

1. Science for knowledge; knowledge for progress

1.1 The inherent function of the scientific venture is to carry out a comprehensive questioning of nature leading to new knowledge. It is this new knowledge that provides cultural and intellectual enrichment and leads to the technological advances and benefits stemming from science. Promoting fundamental research is a priority for achieving endogenous development and progress. There can be no applied science if there is no science to apply.

1.2 Governments should acknowledge the key role of scientific research in the acquisition of knowledge, in the training of scientists and in the education of the public. Scientific research in the private sector has increased, but cannot be a substitute for public research. The public sector should adequately finance scientific research for long-term goals, especially those that are expected to have applications of social importance.

2. Science for peace

2.1 Governments should be aware of the need to apply natural and social sciences and technology to address the root causes of conflict, such as social inequalities, poverty, lack of justice and democracy, inadequate education for all, insufficient health care and food provision, and environmental degradation. Governments should increase investment in these areas of scientific research at the expense of their military budgets. There will never be peace while there is poverty and inequity.

2.2 Scientists should uphold the principle of full and open access to information; scientific research should be subject to public accountability. Those in the scientific community share a long-standing tradition that transcends all borders; it is the basis of a culture of peace. All nations should facilitate the free travel of scientists and recognize their constructive cooperation as a valuable contribution to the peaceful development of human civilization.

3. Science for development

3.1 Governments and the private sector should provide enhanced support for building up an adequate and evenly shared scientific and technological capacity as an indispensable foundation for economic, social and environmentally sound development. Technological development requires a solid scientific basis and needs to be resolutely oriented towards cleaner production and more environment-friendly products. Investment in science and technology, aimed at a better understanding and safeguarding of the planet's threatened life-support system and at integrating the economic, social and environmental objectives of development, must be increased.

3.2 Science education at all levels and without discrimination is fundamental for ensuring sustainable development. In recent years, worldwide efforts have been initiated to develop and strengthen educational programmes to provide all children, youth and adults with basic education. It is on this platform that science education, communication and popularization need to be built. Now more than ever, it is vital to develop and expand scientific literacy with reasoning ability and skills so as to increase public participation in the decision-making process related to the application of new knowledge.

3.3 National strategies and institutional arrangements should be set up to enhance the role of science for development, and in particular: a long-term national policy on science and technology; the creation and maintenance of national authorities for risk assessment, safety and health; and incentives for investment, research and innovation. Parliaments and Governments should provide a sound legal, institutional and economic basis for enhancing scientific and technological capacity.

3.4 All countries, and in particular the developing countries, need to strengthen scientific research in higher education and postgraduate programmes. Regional and international cooperation should be used to support scientific capacity-building to ensure both equitable development and the spread and utilization of human creativity without discrimination of any kind (sex or ethnic origin). All efforts should be made to create conditions that ensure a marked reduction or reversal in the brain drain.

3.5 Progress in science requires various types of cooperation at the intergovernmental, governmental and non-governmental levels, including multilateral projects; fellowships and grants to promote research, particularly in the developing countries; international agreements for the joint funding of megaprojects; international panels for the evaluation of complex scientific results; and international arrangements for the promotion of postgraduate training. New initiatives are required for interdisciplinary collaboration through national and international research facilities, research networks and targeted projects. Support for international collaborative projects, especially those of global interest, should be significantly increased. Access to these facilities for scientists from developing countries should be facilitated.

3.6 National policies on science and technology should encourage all partners, particularly the private sector, to support scientific research and to develop university-industry cooperation. Although intellectual property rights need to be appropriately protected, access to data and information are essential for undertaking scientific work. The development of a universally accepted legal framework is necessary; this should take into account the specific requirements of developing countries with regard to access to scientific information and data.

4. Science in society and science for society

4.1 The practice of scientific research and the use of scientific knowledge should always aim at the welfare of humankind, men and women alike, and be respectful of the dignity of human beings and of their fundamental rights, and take fully into account our responsibility towards future generations; there should be a new commitment in this respect.

DRAFT DECLARATION ON SCIENCE AND THE USE OF SCIENTIFIC KNOWLEDGE *(continued)*

4.2 A free flow of information on the possible uses of new discoveries and newly developed technologies should be secured so that ethical issues can be debated in an appropriate way. In each country a sustainable mechanism should be established to address the ethics of the use of scientific knowledge and its applications.

4.3 All scientists should commit themselves to high ethical standards. The possible development of a pledge for all scientific professions, similar to the Hippocratic oath, should be considered as an expression of this commitment.

4.4 The difficulties encountered by women and by minorities in entering and pursuing a career in science, and in gaining access to decision-making in science and technology, should be addressed urgently through adequate institutional mechanisms and other appropriate measures. Equality in access to science is not only a social and ethical requirement for human development, but also a necessity for realizing the full potential of scientific communities and to orient scientific progress towards meeting the needs of humankind.

4.5 The social responsibility of scientists implies that they exert a rigorous quality control of their findings, share their knowledge, communicate with the public and educate the younger generation. A free flow of scientific information and open access to it should be guaranteed by all parties concerned.

We, participants in the World Conference on Science for the Twenty-first Century: A New Commitment, consider that the Conference document "Science Agenda - Framework for Action" gives practical expression to the new commitment to science, and can serve as a strategic guide for international partnership between all stakeholders in the scientific venture in the years to come.

We commit ourselves to act cooperatively through our own spheres of responsibility to strengthen scientific culture and its peaceful application throughout the world, and to promote the use of scientific knowledge for development, taking into account the societal and ethical principles illustrated above.

We therefore adopt this World Declaration on Science and the Use of Scientific Knowledge and agree upon the Science Agenda – Framework for Action as a means of achieving the goals set forth in the Declaration.

Euro-Mediterranean science and technology cooperation projects

The European Commission published, in 1997, a catalogue which lists joint research projects involving participants from the European Union and the Mediterranean partners (Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, the Syrian Arab Republic, Tunisia, Turkey, and the West Bank and the Gaza Strip). These projects reflect regional trends and capabilities in research and development. The following is an analytical summary of projects undertaken in participation with ESCWA member countries, as well as other Arab countries. The starting dates of the projects covered fall within the period from 1988 to 1996, while ending dates of some of the projects extend up to the year 2000.

The table below shows the number of research projects, according to research topic, which were undertaken in ESCWA members (namely Egypt, Jordan, Lebanon, the Syrian Arab Republic, and the territory under the Palestinian authority), as well as Algeria, Morocco and Tunisia.

Figure I presents the distribution of the total number of projects in which Arab countries participated. From a quantitative viewpoint, Morocco, Tunisia and Egypt participated in a large proportion of the projects covered in the catalogue, followed by Algeria. However, given Egypt's population, 33 projects might be considered a modest share of the total number (19 per cent). The same remark can be made regarding the Syrian Arab Republic, with a project share of only 3 per cent (see figure I). Jordan seems to be active in R and D cooperation, with a total of 11 projects.

Figure II shows the project distribution in ESCWA members with respect to research topics, namely water, soil, environment, energy, agriculture, health, information and communication technology and materials technology. From figure II, it can be seen that water supply and water treatment have the highest share (29 per cent), followed by public health (21 per cent), then by information and communication technology (16 per cent). Research in these areas is crucial to ESCWA. Crop and livestock production and other agriculture-related issues appear neglected, however, especially in Jordan, Lebanon and the Syrian Arab Republic, in comparison with the Maghreb countries. In addition, materials, production technologies and environmental research do not appear to receive much attention anywhere in the region.

Cooperation agreement between Al Seif for Development and King Fahd University of Petroleum and Minerals

A three-year cooperation agreement was signed in November 1998 between Al Seif for Development and King Fahd University of Petroleum and Minerals in Saudi Arabia. Al Seif is involved in the execution of several projects related to the environment, including the installation of air and water pollution measurement equipment, and the disposal of medical wastes. With regard to the University, it includes a centre for waste treatment, as well as an environmental protection section. Through collaboration with the University, Al Seif will benefit from the University's advisory services and environmental research results. The University will have the chance to apply its scientific expertise in the field.

The alliance between institutions of higher education and the private sector is an effective mechanism for enhancing the quality and utility of research and development operations and achieving greater technological compatibility with market demand. This idea was strongly emphasized in the recommendations of the ESCWA Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA Member Countries. The Meeting accentuated the need to investigate novel methodologies for bringing the R and D and business communities in closer and constant contact (see page 10 of this Review for additional information).

TABLE. DISTRIBUTION OF EURO-MEDITERRANEAN RESEARCH PROJECTS ACROSS COUNTRIES AND RESEARCH TOPICS

	ESCWA member countries/areas						*Other Arab countries*				
Research topic	Egypt	Jordan	Lebanon	Syrian Arab Republic	Territory under the Palestinian Authority	*Total*	Algeria	Morocco	Tunisia	*Total (other countries)*	*Total*
Water supply and management, water treatment and pollution control	6	7		3	2	18	8	15	13	36	54
Soils	2					2	1	1	2	4	6
Environmental research and ecosystems	4					4		3	3	6	10
Renewable energy	3	1			2	6	1	3	1	5	11
Crop production, livestock production and other agriculture-related topics	4			1		5	3	10	9	22	27
Public health	5	1	3	1	3	13	6	10	6	22	35
Information and communication technology	6	2	1	1		10	2	5	11	18	28
Materials and production technologies	3					3	1		1	2	5
Total number of projects	33	11	4	6	7	61	22	46	46	115	176

Figure I. Distribution of Euro-Mediterranean S and T cooperation projects across Arab countries (1988-1996)

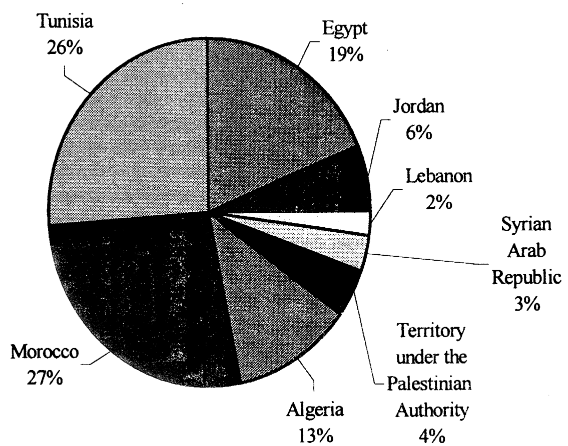
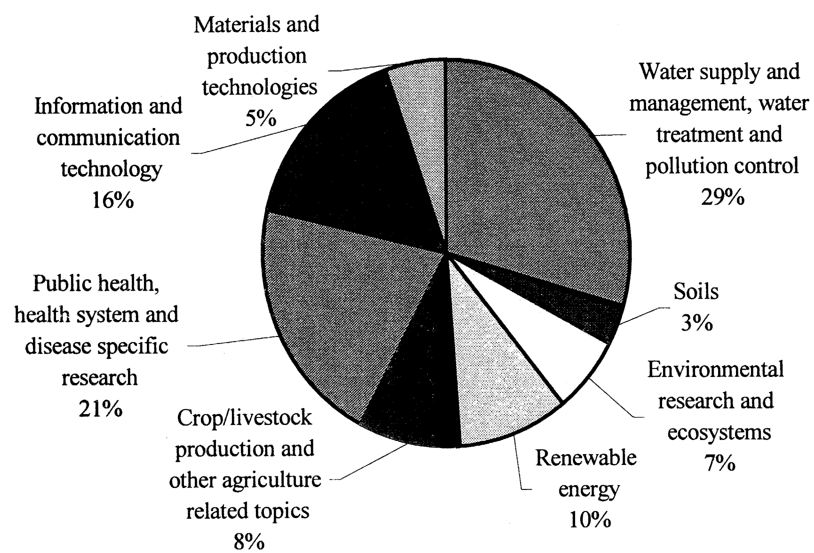


Figure II. Distribution of Euro-Mediterranean S and T cooperation projects across research topics in ESCWA member countries



This paper[1] was presented at the Expert Group Meeting on challenges and Opportunities of WTO (World Trade Organization) for ESCWA Member Countries in Selected Sectors. The Meeting was organized by ESCWA, the Arab Planning Institute in Kuwait, and the German Friedrich Naumann Foundation, and was held in Kuwait from 24 to 26 November 1997.

The world pharmaceuticals industry

Global production of pharmaceuticals is a sizeable industry, largely concentrated in a limited number of countries and multinational companies. In 1994, companies based in only seven industrialized countries[2] accounted for more than 84 per cent of the global market, estimated at US$ 237 billion[3] [1]. With an annual growth rate of around 10 per cent, global production of pharmaceuticals must now exceed the US$ 300 billion mark.

Economic and regulatory pressures faced by global industries appear to have constrained their growth and to have provoked increasing merger and acquisition activity. As a result, the smaller producers have become more vulnerable and less capable of matching the innovative capabilities of the industry's giants.

The rate of discovery of new chemical entities has declined considerably since the 1960s and 1970s. This has resulted in slowing down the rate of new drugs entering the market. Furthermore, increasingly stringent pre-clinical and clinical testing of new chemical entities before they are allowed on the market has resulted in reduced effective patent lives and hence decreased profitability.

The pharmaceuticals industry is renowned for its high costs at both ends of the business system [2]. That is in R and D, as well as in marketing and distribution. The cost of developing an entirely new drug is now estimated at around US$ 300 million [2]. It is due to such high development costs that pharmaceuticals producers will, generally, focus on drugs' expected results in revenues exceeding US$ 500 million [2].

Therefore, enhanced acquisition and merger activity, combined with decreased productivity and longer development time, for new chemical entities, may be expected to precipitate a fall in the number of firms and a lowering of the industry's innovative output [1].

A focus on innovative drug delivery, formulation and packaging systems of both new drugs, as well as generics, is among the survival strategies being pursued by the industry. Smaller producers have tended to adopt niche positions, focusing on a more limited set of therapeutic classes or methods of drug delivery [1].

Tighter protection of patents and intellectual property rights at the global level are among measures targeted by multinationals with over-support from their home Governments in order to derive maximum benefits from their established positions of technological superiority.

The pharmaceuticals industry in the region

Pharmaceuticals production in the Arab countries is a relatively small industry by international standards, constituting around 0.7 per cent of the world's output.[4] Figure I provides a view of production and consumption in a number of Arab countries. The pharmaceuticals industry experienced considerable growth in a number of Arab countries during the late 1980s and early 1990s, and that growth has continued.

Thus, with over 120 pharmaceuticals factories in actual operation throughout the Arab countries, 30 new production plants are under construction in only 12 countries (see figure II).[5] The phenomenal growth in the Saudi Arabian, Syrian and Jordanian industries is noteworthy. Around 27 pharmaceuticals factories have been established in the Syrian Arab Republic since 1990. Jordanian manufacturers set up five factories in the 1980s and early 1990s and a further five were to start production in 1997. Production capacity of private sector manufacturers in Egypt also exhibited dramatic increases.

[1] The paper is based on the study published by ESCWA on the Challenges and Opportunities of the New International Trade Agreement (Uruguay Round) for ESCWA Member Countries in Selected Sectors: Implications of WTO/TRIPS for Technology Transfer in the Pharmaceutical Industry (E/ESCWA/TECH/1997/7).

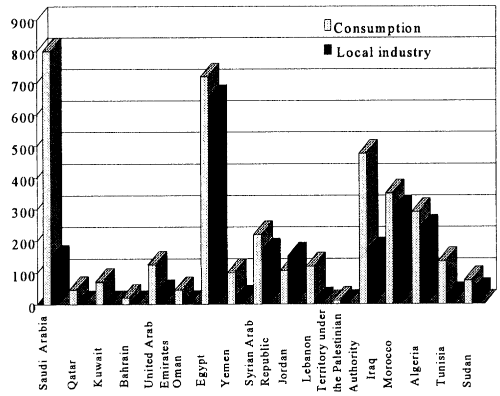
[2] France, Germany, Japan, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland and the United States of America.

[3] The figure for 1995 was US$ 286 billion.

[4] With the exception of Egypt, most other countries in the region initiated their own pharmaceuticals operations largely during the 1960s and 1970s.

[5] Algeria, Egypt, Iraq, Jordan, Lebanon, Morocco, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, the United Arab Emirates and Yemen. Eight of them are ESCWA members, namely Egypt, Iraq, Jordan, Lebanon, Saudi Arabia, the Syrian Arab Republic, the United Arab Emirates and Yemen.

Figure I. Consumption and local industry production in pharmaceuticals for selected Arab countries and areas [3]

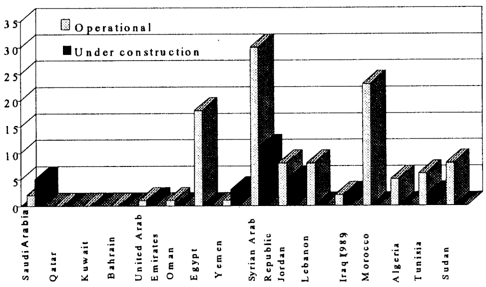


The number of brands manufactured by Syrian producers grew from around 350 in 1983 to about 600 in 1990. An even higher rate of growth was witnessed during 1995 and 1996,[6] so that nearly 2,500 brands are currently produced by the Syrian Arab Republic's pharmaceuticals industry, which covers an estimated 75 per cent of this country's needs[7] [3]. Nearly 260 production lines are said to be in operation in a total of 44 plants belonging to both the public and private sectors [4]. Established Jordanian pharmaceuticals manufacturers produce around 345 brands. With the exception of the Jordanian industry, which exports nearly 75 per cent of its output, the industry in the region is largely geared to meeting domestic consumption. An overview of technological capabilities possessed by domestic producers in the region is contained in box 1 below.

Ownership patterns

Different patterns of ownership of production enterprises may be observed in the countries of the region. Both public and private sector enterprises may be found, with the number of the former generally declining in favour of the latter. Multinational producers are also present. Joint venture production in Egypt in 1996 covered around 20 per cent of local needs, while the share of public sector producers was around 41 per cent and the private sector produced around 34 per cent of market needs. The Syrian Arab Republic's industry is largely dominated by private sector enterprises. Jordan's pharmaceuticals industry is totally owned by the private sector [2].

Figure II. Pharmaceuticals production facilities in operation and under construction in selected Arab countries [3]



Licensed production of pharmaceuticals

In Egypt, 40 per cent of drug formulation and packaging activities are carried out under licensing agreements with multinational companies. Jordan, however, produces only 2 per cent of its output under licence.

A closer look at the spectrum of products manufactured under licence in the region indicates that product groups are targeted mainly because of economic considerations. A considerable number of drugs are produced by more than one firm in a given country with consequent profitability losses at the national level.

Licensing is alleged to have made limited contributions to building modern technological capabilities in pharmaceuticals production in the region. Several instances may be quoted in which:

- Technology transfer has not been extensive and has tended to concentrate in traditional areas of production technologies;
- A combination of governmental regulatory measures and licensing arrangements governing raw materials' prices, as well as procurement practices, has negatively affected domestic producers' profitability, ultimately hindering the expansion of their technological capabilities;
- Licensing arrangements concluded by domestic producers in the past have been

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[6] The number of drugs registered with health authorities in the Syrian Arab Republic exceeded 20,000 in 1963. These drugs were imported from producers all over the world. This figure was brought down to about 3,800 by 1973 [4].

[7] Higher estimates have been reported, for example, by Fadloun [4].

devoid of provisions for advanced quality control and laboratory facilities. [8]

Box 2 summarizes some of the main difficulties encountered by local pharmaceuticals manufacturers in the region.

Box 1. Technology-related characteristics of the pharmaceutical industry in the region

- Domestic producers are mostly small- to medium-sized firms specializing, principally, in packaging, with, so far, limited formulation activity. The spectrum of pharmaceuticals produced by domestic producers is largely confined to generics.
- Production is largely based on imported active ingredients [2]. Little, if any, of the industry's equipment and raw materials are produced locally and most production and packaging equipment, as well as a large proportion of packaging and auxiliary materials, is imported.[a/]
- Research activities carried out by and for the industry, the latter principally by public research institutions, are few. Development activity is known to have been a factor in a limited number of cases.[b/]
- In a considerable number of instances, licensing activity by domestic industry, particularly during the late 1980s and early 1990s, served to accelerate the adoption of good manufacturing practices at the national level. This may also have catalysed moves, on the part of health authorities, to develop, adopt and enforce national codes for good manufacturing practices. Producers in several countries in the region are reported to have made commitments to obtain ISO (International Organization for Standardization) certificates. Some have already acquired ISO 9002 certification.

a/ This accounts for the fact that value added by local producers is considered to be on the low side. In the case of Egyptian industry, for example, it is estimated to be about 35 per cent [5].

b/ One patent is known to have been granted, during the 10-year period 1980-1989, to an Egyptian research institution in relation to a natural product-based preparation [6].

Regulatory framework

The pharmaceuticals sector in the region witnessed significant moves towards liberalization. An example of this may be quoted from the Syrian Arab Republic, where regulations governing the private sector's operations have undergone repeated revisions towards liberalization. Efforts aimed at further liberalization, particularly with respect to price controls and the ending of State subsidies, are faced with resistance on several fronts. State protectionism, as applied to the pharmaceuticals sector in Egypt, for example, is rooted in the fact that the industry is the sole source of inexpensive drugs for large segments of limited-income populations [5].

[8] Industrial operations covered by such licensing arrangements generally involve traditional operations within a mature production environment.

Box 2. Difficulties encountered by local pharmaceuticals manufacturers in the region

- High levels of local competition and replication within confined therapeutic categories;
- Lack of cooperative activity among pharmaceuticals producers in strategic production planning and marketing;
- Emphasis on short-term investment based on low-barrier products with limited technology inputs targeting low-income consumer groups;
- Government regulations that rightly target pricing with welfare considerations in mind, but do not accord sufficient attention to meeting long-term technology needs of the industry;
- Lack, or weakness, of intellectual property regimes in the region, which may have discouraged greater involvement by multinational corporations with consequent long-term effects on product quality;
- Difficulties due to limited market sizes, exacerbated by lack of national and regional coordination, which have resulted in excess capacity and low profitability;
- The fact that although significant efforts have been made for the adoption and application of standards for good manufacturing practices in many countries in the region, a good deal of effort is still needed in order to achieve internationally acceptable standards.

The TRIPS Agreement and the pharmaceuticals industry

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was a principal outcome of the Uruguay Round, 1987-1993, which resulted in the General Agreement on Tariffs and Trade (GATT) and the establishment of the World Trade Organization (WTO). It is considered "the most ambitious international instrument on IPRs (*Intellectual Property Rights)* ever negotiated" [2].[9] The objectives of TRIPS, as set out in article 7 of the Agreement, are that

> "The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations".

Strengthening intellectual property protection in pharmaceuticals was a principal concern in negotiations of the TRIPS Agreement during the

[9] Italics by the author.

Uruguay Round. It continues to be the object of many post-TRIPS multilateral and bilateral discussions.

Anxiety in the pharmaceuticals industry in the developing countries is often expressed regarding:

- Pressure exerted by some multinational corporations supported by their home Governments for the immediate introduction of the TRIPS standards;

- Frequent calls for the application of the TRIPS standards retroactively and for the prolongation of the term of protection, beyond the 20 years required by the Agreement in relation to certain pharmaceutical products;

- The need to attract foreign direct investment (FDI) and encourage effective technology transfer in modern pharmaceuticals, with the aim of import-substitution, as well as export-oriented manufacturing.

Pharmaceuticals industries in the region have been unanimous in demanding maximum possible delays in the application of TRIPS provisions to the production of pharmaceuticals. Compliance with TRIPS provisions entails drastic revision of intellectual property rights legislation in the Arab countries. However, while this appears to be biased in favour of the immediate concerns of the industrialized countries, it may, in the long term, be in the interest of all operators. Signing the TRIPS Agreement and developing reliable means for the enforcement of its provisions will not be sufficient to guarantee a rosy future for the industry, even in the long term. It will also be essential to synchronize such activities with measures aimed at reviewing technology transfer, as well as R and D policies and practices.

Several Arab countries are in the process of formulating or revising legislation aimed at higher levels of protection for intellectual property rights, an area which is still in a somewhat nascent stage. Measures designed to enforce whatever laws that do exist are in need of considerable attention.

Research and development activity in the pharmaceuticals industry

The global pharmaceutical industry is R and D-intensive. Global expenditure on R and D is estimated to have reached around US$ 24 billion in 1991. Most of the industry's R and D expenditure, and hence innovative activity, is concentrated in a small number of multinational corporations in a few countries. Producers in only 11[10] countries shouldered over 90 per cent of global R and D expenditure in 1991. Japanese, British and American companies originated 70 per cent of the leading medicines in the 75 major product groups [1].

R and D expenditure relative to the industry's revenues has generally grown at considerable rates.[11] Currently, the ratio of global R and D expenditure to sales stands at around 14 per cent. Growth in R and D has generally focused on:

- The development of new chemical entities;

- Drug delivery systems enjoying greater efficacy and action site specificity;

- Production processes for a variety of specialities and generics.

Discoveries in microbiology and genetics are constantly being investigated with a view to providing the industry with new routes for drug synthesis. Innovations in computer technology have also been instrumental in providing pharmaceuticals researchers with powerful new tools for molecular modelling and the design of complex synthetic routes, as well as the simulation of drug interactions.

While powerful computer facilities and other R and D prerequisites will certainly carry a high price tag, it should be noted that emerging drug development paradigms based on novel discoveries in the life sciences are expected to make drug design and interaction studies less costly and thus more accessible.

With the exception of reports on R and D activities carried out by relatively under-financed public research programmes in a few countries in the region,[12] little or no R and D appears to be taking place that is of direct benefit to the industry. Owing to their high cost, R and D activities on new chemical entities aimed at developing entirely new pharmaceuticals must be considered beyond the means of any one firm in the Arab countries. Limited export potential and small/fragmented domestic markets will tend to reinforce a trend towards adaptive, rather than

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[10] Belgium, Denmark, France, Germany, Italy, Japan, the Netherlands, Spain, Switzerland, the United Kingdom and the United States.

[11] This rate averaged 15 per cent during 1980 - 1991 in 11 of the leading producer countries. During the same period the ratio of R and D expenditure to sales figures rose from 10 per cent in 1981 to 14 per cent in 1986. It is reported to have levelled off at this value [1].

[12] Mostly targeting the extraction and packaging of active material extracts from naturally occurring substances in endogenous plants.

innovative, R and D activities. Original R and D activities may be addressed only in a limited number of areas in which the countries of the region face urgent needs or possess distinct comparative advantages. In the latter group of activities, it will be worthwhile for the Arab countries to target R and D potential in areas such as the natural, as well as genetically modified animal- and plant-based products. An allied field is the investigation of the molecular structures of active components and methods for their extraction, purification and replication.

The future

Estimates of drug consumption in the region indicate rises due to population growth and higher health standards. Qualitative changes in therapeutic categories will also be fuelled by socio-economic and demographic changes in the region. Major expansion into new therapeutic categories in the second half of the next decade is contingent upon local developments with respect to IPRs regimes and compliance with TRIPS regulations. In the meantime, the future of numerous operations in the region hinges upon a multitude of factors. The stance adopted by foreign patent holders, as well as the bargaining position of domestic producers, will be instrumental in deciding the fate of production activity that is unprotected by licensing agreements. Otherwise, an ability to switch to alternative product repertoires will be paramount in determining the chances for survival of domestic industries.

Endogenous industry-specific R and D capabilities in the region need to be created and strengthened, with emphasis on adaptive R and D endeavours. Limited original activities on natural products and new chemical entities derived therefrom could produce longer-term dividends. Conducting such activities in alliance with established R and D partners, both in and outside the regions, may produce decided benefits. To this end, emphasis needs to be placed upon R and D cooperation at the national, regional and international levels and fresh government/industry initiatives have to be launched. Box 3 includes a list of R and D priorities for the pharmaceuticals industry in the region.

The long-term future of the pharmaceuticals industry in the region hinges on its ability to access modern production and packaging technologies, as well as the acquisition of viable R and D capabilities. Initiating R and D and distribution alliances with established international operators, difficult as it certainly is, will also be of considerable benefit in improving the industry's chances for survival.

Box 3. R and D priorities for the pharmaceuticals industry in the region

- Adaptive R and D activity aimed at both formulation and active material development and modification. R and D in the latter category may be aimed at the introduction of incremental structure changes into molecules of known physiological properties with a view to altering side-effects and absorption characteristics;
- Adaptation of new delivery systems and new modalities for administering;
- Safety and preservation studies, as well as packaging and site-specific delivery systems which constitute other related areas of activity;
- Production process improvements targeting generic drugs and their raw materials, including the introduction of higher degrees of automation and computerization in production and quality control.

Establishing modern distribution networking on the basis of regional and subregional industry alliances may well be rewarded at two levels: greater complementarity at regional and subregional levels, as well as possibilities for interfacing with larger global networks, thus facilitating and reducing the cost of both import and export of pharmaceuticals.

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The Y2K problem at a glance

The year 2000 problem, Y2K for short, involves a hardware/software bug, whereby a system uses only two digits for the dates, and hence cannot tell the difference between the year 1900 and the year 2000. On 1 January, in the year 2000, the system will cause errors in data and in some cases, could stop functioning. While this problem will seriously affect transaction-based systems in areas such as banking, it will also extend to a large number of control systems in place around the world. Hence remedies may not only be costly, but could also involve significant risk.

The United Nations General Assembly resolution

At its fifty-second session, the General Assembly adopted, on 26 June 1998, resolution 52/233 on global implications of the year 2000 date conversion problem of computers. In its resolution, the General Assembly recognized the potentially serious impact of the year 2000 problem on the operation of Governments, companies and other organizations, and consequently all countries' economies. The Assembly underlined the need for effective action and coordination between Governments and organizations to address the problem. All member States were requested to attach high priority to the issue, share their experiences and coordinate their efforts. In the resolution, the Assembly also requested the Secretary-General to take steps to ensure that all parts of the system were year 2000 compliant well before the target date. The Economic and Social Council was requested to prepare guidelines for the Member States on the diverse aspects of the year 2000 problem.

The guidelines of the Economic and Social Council

In an annex to a draft resolution submitted at its 1998 session (E/1998/L.40), the Economic and Social Council adopted guidelines for addressing the year 2000 problem, in response to General Assembly resolution 52/233. The suggested four-step procedure is outlined as follows.

1. *Problem awareness*

The year 2000 awareness should be initiated at all levels of Government and the private sector. Progress should be publicly and regularly reported.

2. *Problem assessment*

Sectors of primary importance should be identified and assessed against their compliance with the year 2000 problem, and interdependencies between systems should be identified.

3. *Problem solution*

Manpower and budgetary resources required for the conversion into year 2000 compliant systems should be determined. Validation and testing steps should be designed and applied.

4. *Contingency planning*

Contingency plans and back-up arrangements should be established, especially for critical systems, in order to avoid data loss.

Regional action

Several countries in the region have become aware of the problem and are taking serious steps in this regard. For example, Saudi Arabia has established a national committee which meets weekly in order to develop a plan and create awareness of the problem. A national conference was also held on 27 and 28 April 1998.

Public institutions have been requested by the authorities in the Syrian Arab Republic to assess their year 2000 problem and develop and implement a solution. Regular progress reports have been requested by the Prime Minister. A national conference was held on 10 and 11 March 1998 with the principal aim of enhancing awareness of the problem among the concerned parties.

Expert Group Meeting on Science and Technology Policies for the Twenty-first Century 10-12 March, 1999

Background

Science and technology policies play an essential role in facing challenges that are increasingly affecting the region, including increased competition, vanishing trade barriers, more stringent intellectual property regimes and a deeper concern for the environment. However, S and T policies in the region remain inadequate, at best immature, to deal with these challenges. In addition, only a small number of Arab countries have explicitly linked these policies with national development plans.

Objectives

The main objective of the Expert Group Meeting is to refine endogenous capabilities aimed at the formulation and implementation of science and technology policies at relevant levels and in sectors of primary concern in the Arab countries. Prominence will be given to the integration of S and T policies with national development plans and the creation of inward and outward linkages for policy implementation. In addition, the Meeting will provide the opportunity to initiate preparations for the World Conference on Science for the Twenty-first Century: A New Commitment, to be held in June 1999.

The Meeting will adopt a mixed format, combining the format of an expert group meeting with that of a high-level workshop, with a view to accommodating two types of input. First, presentations will be commissioned to highlight new concepts and recent national, regional and international experiences in science, technology and innovative policies. Secondly, syndicate sessions will consider case-studies aimed at promoting familiarity with methodologies for the formulation of S and T policies, as well as their integration within national development plans and their ultimate implementation through appropriate plans and programmes.

Cooperating organizations

ESCWA, the UNESCO Cairo Office, the Arabian Gulf University, Arab Fund for Economic and Social Development, Kuwait Foundation for the Advancement of Sciences and the Lebanese National Council for Scientific Research.

Organization of the Meeting

Day 1 — 10 March 1999

Registration, inauguration speeches and welcoming reception.

1. Keynote address.

Presentations (I):

2. S and T policies and strategies: models and modalities.
3. National innovation systems.
4. Syndicate sessions (I):

   National innovation systems, technology diffusion/ blending, new technology inputs for sustainable development, micro, small and medium enterprises.

Day 2 — 11 March 1999

Presentations (II):

5. Critical analysis of experiences in the formulation of S and T policies and strategies in the Arab region.
6. Models for the design and implementation of national S and T policies.
7. Syndicate sessions (II):

   Policy and strategy formulation and implementation.

Day 3 — 12 March 1999

Presentations (III):

8. Implementing S and T policies and strategies.
9. Syndicate sessions (III):

   Policy and strategy formulation and implementation (*continued*); networking; policy instruments.
10. Presentation on the World Conference on Science for the Twenty-first Century.[a]
11. Finalization and panel discussion of syndicate reports, recommendations and action plans.
12. Closing remarks.

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a/ For more information on the Conference, see p. 14 of this Review.

Contact information

Requests for additional information concerning the Meeting should be addressed to the following:

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Production and quality assurance technologies in selected segments of the food industry 1999

Background

The agro-food industry is awarded priority status in all ESCWA member countries owing to the magnitude of the region's food demand and the nature of its climatic and environmental characteristics. However, the technologies used in this industry are still largely in need of further development.

Objectives

The study will characterize the state of production, standardization and quality assurance technologies in selected ESCWA member countries and in chosen segments of the food industry. Biotechnology and information technology will be given prominence in the study. Candidate food industry segments include the dairy and the vegetable and fruit canning industries. The level of conformity with local and international health and safety standards in these segments will also be considered.

On the basis of the above assessment, areas in need of priority attention will be identified. The need to introduce, adapt and disseminate new technologies in agriculture and food production will be looked at with a view to promoting higher levels of safety, quality, and environmental compatibility.

Expert Group Meeting on Project Planning and Management in Research and Development and Quality Assurance 1999

Objectives

The Meeting is aimed at developing, with the help of experts/resource persons invited to the Meeting, a framework for project planning and management in R and D and quality assurance (QA) activities, taking into account prevailing conditions and perceived challenges in the ESCWA member countries.

The purpose will be to help establish certain institutions as focal points, or hubs, in national and subregional training networks for R and D and QA training in the ESCWA member countries.

Areas of emphasis

The Meeting will address the following issues:

1. Principles of R and D and QA management;
2. Evaluation of the state of R and D and QA management in the member countries;
3. Evaluation of current practices and schools of thought, with information about their evolution;
4. Strategies for the acquisition of enhanced capabilities in R and D and QA management.

Study on Environmentally Sound Technologies in Selected Production and Services Sectors 1999

Objectives

The study will cover environmentally sound technologies (ESTs) in selected branches of the agro-food industry. Areas of emphasis are resource conservation, environmental protection and new international environmental standards. Business opportunities for small and medium enterprises arising from the introduction of the targeted ESTs will be highlighted.

The ESCWA Technology Section produced several publications as official outputs of its work programme during the biennium 1996-1997. Copies of these publications may be obtained from the ESCWA Conference Services Section or through the Technology Section at the address listed on the back of the inside cover of this Review.

Biotechnology in the ESCWA Member Countries: Sectoral Issues and Policies
(E/ESCWA/TECH/1997/1)

The study provides an account of recent trends in biotechnology that are of interest to the ESCWA member countries. The first part of the study focuses on agro-biotechnology, an area that is of vital importance given the ecological conditions prevailing in the region. Technical and financial developments in genetic engineering techniques and plant tissue culture are highlighted. Surveys of the status and capabilities in biotechnology in the ESCWA member countries are also summarized, with emphasis on the development of national policies for technology transfer, development and adaptation. The second part of the study focuses on industrial and medical applications of biotechnology, which are mostly applications of enzyme and bioreactor technologies.

Environmentally Sound Technologies in the Tanning Industry
(E/ESCWA/1997/2)

The ultimate objective of the study is to provide the ESCWA member countries with information on new environmentally sound technologies with the potential for improving the environmental profile of the tanning industry, an extremely polluting and water-consuming industry in the member countries. Throughout the seven chapters of the study, the following topics are reviewed:

(a) An outline of the principal stages in leather manufacture, with particular attention given to beamhouse and tanhouse processes and a detailed analysis of the environmental impact of the various tanning operations, with particular emphasis on solid and waterborne wastes;

(b) An overview of recently developed environmentally sound alternative technologies in current use; these re-engineered processes use entirely new materials and can improve quality and profitability, as well as reduce water consumption and waste;

(c) A review of the two sources of development in the tanning industry, namely information technology and research activities;

(d) A review of global and regional trends with respect to net flows of raw materials and finished products in the tanning industry.

The study also includes an assessment of the tanning industry in Jordan and the Syrian Arab Republic, including production capacities, pollution levels and pollution treatment methodologies.

The study concludes with a set of recommendations aimed at facilitating the move towards cleaner technologies, as follows:

1. Promoting local technology inputs: intensive and ongoing involvement on the part of institutions and individuals concerned with local technology development is of the essence in the modernization of the tanning industry.

2. Providing for the R and D needs of the industry: the above-mentioned goals can only be achieved by setting up effective research and technology development capabilities dedicated to the industry's needs.

3. Research and development and partnership between R and D institutions and industry.

4. Responding to an institutional vacuum: institutions are needed that will galvanize and integrate efforts by manufacturers, professional societies, importers, exporters and consumers in a variety of areas, including information dissemination, training and technology acquisition as well as fashion and design exhibitions.

5. Joint tasks for governmental and non-governmental organizations: the role of governmental and non-governmental organizations in promoting the acquisition of environmentally sound technologies must be subjected to serious review.

6. Information: a facility should be established to disseminate information on environmentally sound technologies in the leather industry and efficient two-way communication between users, and

custodians/operators of such an information system should be ensured.

7. Funding technology development: adequate and constant funding arrangements should be secured for technology acquisition and R and D activities aimed at upgrading the industry's environmental performance.

8. Private enterprise: assistance should be provided to private enterprises engaged in adaptation and dissemination of environmentally sound technologies, including those based on computer automation for the industry.

9. Better use of efforts made by international organizations: providing links to the United Nations and other international and regional organizations concerned with the environment and industrial development is another task that has to be carried out with greater efficacy and continuity.

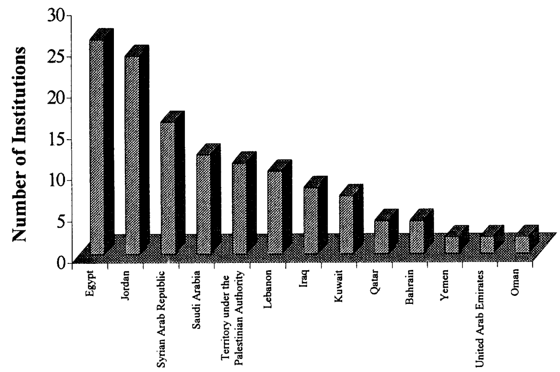
10. Formulation and enactment of workable legislation: legislation for the protection of health and the environment should be based on a sound understanding of the chemistry and the risks associated with the pollutants involved.

Directory of Research and Development Institutes in the ESCWA Member Countries
(E/ESCWA/TECH/1997/4)

The directory of research and development institutions (ESCWA-DRI) is primarily intended to promote coordination and cooperation among R and D institutions and provide information about their activities. It is based on a survey covering over 200 R and D institutions as well as national and regional organizations supporting R and D activities. Detailed responses were obtained from around 56 R and D centres. Additional information was obtained by ESCWA on a group of 72 institutions from a variety of sources. Information presented in the directory includes the mission, structure, activities, staff, publications, services and affiliations of these institutions. Future efforts will be aimed at the continuous updating of the information contained in the directory as well as its publication in electronic format.

Figure I represents the distribution of the R and D institutions included in the directory across the ESCWA members. Figure II depicts institutions by category (national, regional or international) and by links to government (governmental, non-governmental or mixed).

Figure I. Distribution of R and D institutions across ESCWA members



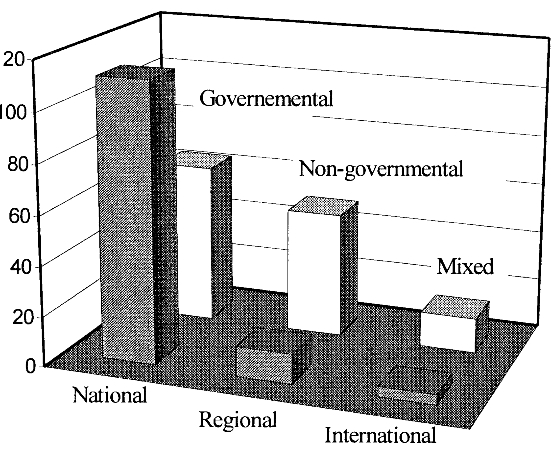
Assessment of Research and Development in Selected ESCWA Member Countries: Local Technological Inputs
(E/ESCWA/TECH/1997/5)

The study assesses R and D in selected ESCWA member countries through a review of the organization, activities, outputs and linkages of a number of concerned institutions in these countries. It is based on a survey of a wide spectrum of R and D institutions in the ESCWA member countries and, on material provided by a number of major R and D institutions, as well as interviews with managers, planners and research personnel in five ESCWA member countries. Information about specific R and D activities carried out, or being completed, in a number of institutions, is presented in various parts of the study with the aim of gaining a deeper understanding of the major obstacles facing R and D activity in the country concerned.

Science and Technology Indicators: Basic Concepts, Definitions and Prospects for Development
(E/ESCWA/TECH/1997/6)

The study reviews the basic notions and terms involved in measuring the performance of the "S and T system" and evaluates recent endeavours aimed at developing and utilizing S and T indicators. The main classes of indicators and their attributes are considered, including indicators for higher education, R and D, S and T demand, international cooperation in S and T, and S and T policy formulation. The objective of the study is to revive interest in an improved set of S and T indicators that will better enable the region to meet the new challenges and opportunities. The S and T indicators currently in use tend to be biased towards input and supply considerations rather than output and demand aspects. This is probably due to scarcity of data on the latter two aspects, as well as intrinsic difficulties in interpreting information on output and demand. It should be noted that the systems of S and T indicators currently in use do not contain adequate provisions for evaluating the qualitative aspects of an S and T system. Whereas quantitative data are important for the higher education and R and D assessment exercise, they cannot constitute alone a criterion on which to base decisions regarding national development priorities. Therefore, the study also investigates indicators that have greater specificity and responsiveness to the exercise of measuring S and T capacity-building.

Figure II. Distribution of R and D institutions by type



Challenges and Opportunities of the New International Trade Agreements (Uruguay Round) for ESCWA Member Countries in Selected Sectors: Implications of WTO/TRIPS for Technology Transfer in the Pharmaceutical Industry
(E/ESCWA/TECH/1997/7)

The study is part of a multisectoral activity undertaken by several divisions within ESCWA with the aim of assessing the implications of WTO rules and related agreements on selected sectors in the ESCWA member countries. The study focuses on the implications of the Trade-related Aspects of Intellectual Property Rights for technology transfer activities in the pharmaceutical industry. In its introduction, the study provides an overview of the global pharmaceutical industry. The first part of the study addresses the implications of WTO rules on trade, investments and technology, and provides a summary of pharmaceutical production and consumption patterns in the region. Patent regimes and provisions related to the protection of intellectual property rights are also reviewed, and an analysis is made of the impact of the new rules on foreign direct investment, innovation, and technology acquisition. The second part of the study is concerned with pharmaceutical production and consumption in the ESCWA region. Two case-studies are presented, providing a closer perspective on the pharmaceutical industry in both Egypt and the Syrian Arab Republic.

Results excerpted from this study and other papers regarding the pharmaceutical sector in the ESCWA region are summarized in the article on "The pharmaceuticals industry in the ESCWA member countries" contained in this Review, (page (23)).

Research and Development Systems in the Arab States: Development of Science and Technology Indicators (E/ESCWA/TECH/1998/3) **and Higher Education Systems in the Arab States: Development of Science and Technology Indicators**
(E/ESCWA/TECH/1998/Rev.1)

This two-volume study is an update and expansion of an earlier study prepared in 1995 by ROSTAS, the UNESCO Cairo Office, titled "The Development of Science and Technology Indicators for Higher Education and R and D in the Arab States". The new study was published in collaboration with ESCWA. Boxes 1 and 2 below provide a brief listing of the contents of the two volumes. Excerpts from the data included in the R and D study can be found on page 5 of this Review (see figures I and II).

Box 1. Contents of the study on "Higher Education Systems in the Arab States: Development of Science and Technology Indicators"

- Organization of higher education;
- Degree structure of higher education;
- Emerging trends in higher education systems;
- Student enrolment and graduates in higher education;
- Higher education S and T indicators;
- Indicators of staff members and staff/student ratios.

Box 2. Contents of the study on "Research and Development Systems in the Arab States: Development of Science and Technology Indicators"

- R and D Systems under review
- Organization of R and D
- R and D policy-making bodies
- R and D policy issues
- R and D agenda
- R and D implementation
- Autonomous R and D units
- University R and D units
- Non-governmental and/or private sector units
- R and D units by major field groups
- Distribution of R and D units by State
- Distribution of R and D units by name
- R and D expenditure
- Sources of R and D funding
- Emerging R and D funding modalities
- R and D expenditure ratio to GDP
- Sectoral R and D expenditure
- R and D personnel
- FTE researchers
- R and D indicators
- Percentage of R and D expenditure (R and DE) of GDP
- Percentage share of Government of R and D expenditure
- Growth of R and D expenditure
- R and D expenditure per capita population
- R and D expenditure per FTE researcher (FTE researcher cost)
- FTE researchers per 1,000 labour force
- Research personnel per 1,000 labour force
- Percentage of government FTE researchers of total
- Percentage of university FTE researchers of total
- Percentage of private sector FTE researchers of total
- Methodologies

Note: FTE = full-time equivalent.

Projected activities of the ESCWA Technology Section for the biennium 2000-2001

The current medium term plan at ESCWA, covering the period 1998-2001, sets the following five goals:

1. Management of natural resources and environment;

2. Improvement of the quality of life;

3. Economic development and global changes;

4. Coordination of policies and harmonization of norms and regulations for sectoral development;

5. Development, coordination and harmonization of statistics and information.

Within the context of these goals, the following objectives were set for the Technology Section:

1. To strengthen the capabilities of Member States in technology policy;

2. To assist in ensuring effective transfer of technology;

3. To promote research and development activities, their networking and linkages to the production sector.

Planned activities for the Technology Section during the biennium 2000-2001 will continue to focus on the objectives set for the medium-term plan. The following activities are being proposed:

1. Study and expert group meeting on technology initiatives in the ESCWA member countries: methodologies for formulating, implementing and monitoring national, regional and international technology initiatives will be addressed by these two activities.

2. Study on water desalination and water treatment technologies in the ESCWA member countries: the study will characterize the state of production and quality assurance technologies used for water treatment in the region with a view to promoting better economics and higher levels of safety and environmental compatibility.

3. Workshop/expert group meeting on project planning and management in research and development (R and D) and quality control (QC) institutions: the workshop is intended to enhance the capabilities of R and D and QC units in the region for dealing with projects under contract situations.

4. Study on environmentally sound technologies in selected sectors/segments: The study will select a vital sector in the region and examine the possibilities offered by new technologies for resource conservation and environmental protection.

5. Study on new technologies for enhanced competitiveness and productivity in selected sectors: the study will target active segments that could be threatened by the WTO/TRIPS rules and will examine new technologies for enhancing their quality, productivity and competitiveness.

ESCWA staff members take part in conferences and expert group meetings that fall outside regular activities but within areas of current interest to the work programme. During 1998, ESCWA staff participated in, and contributed to, the following meetings which relate directly to the mandate of the Technology Section.

Commission on Science and Technology Panel on Science and Technology Partnership for National Capacity-Building, Malta, 28-30 September 1998

The Panel was organized by the United Nations Commission on Science and Technology Development and involved members of the Commission and other United Nations bodies, as well as experts from the academic community. The Panel included three substantive sessions, the first comprising a general overview of S and T partnerships, the second dealing with S and T partnerships in the energy sector, and the third concerning partnerships in biotechnology.

Conference on Science, Technology and Society Lebanon, 26-28 November 1998

The Conference was organized by the American University of Beirut and focused on the following six themes:

1. Science policy and the management of science;
2. Science and technology between the public domain and the private sector;
3. Women, gender and science;
4. Science in individual and public health choices;
5. Scientific literacy and science education;
6. Global issues in science and technology.

The organizers were scheduled to publish the proceedings of the Conference early in 1999.

The Second Conference on Industrial Research and Development, Lebanon 13-15 November 1998

The Conference was organized by the Lebanese National Council for Scientific Research, in cooperation with the Association of Lebanese Industrialists and the Friedrich Ebert Foundation. The Conference consisted of seven substantive sessions dealing with: philosophy and policy of R and D, accreditation systems for engineering education, technology transfer and registration of patents, software development in Lebanon, the incubator as a bridge between research and industrial application, experiences from Lebanese industry in research, development and management, and R and D as a strategy of coexistence with globalization.

ESCWA staff presented two papers titled: "Research and Development in the ESCWA Region" and "The Importance of Creating a Technology Incubator for Research and Development".

Conference on Scientific Research and Technological Development: Enhancing Competitiveness of the Industrial Sector in the Gulf Cooperation Countries Bahrain, 12-14 October 1998

The Bahrain Centre for Studies and Research held a Conference on Scientific Research and Technological Development in Bahrain from 12 to 14 October 1998, in cooperation with the Arab Gulf University, the member countries of the Gulf Cooperation Council, the United Nations Development Programme (UNDP), and UNIDO. The Conference was attended by a large number of participants from different institutions including R and D, industrial and international organizations.

Major areas of emphasis were:

(a) Management of scientific research and technological development;

(b) Experience of major R and D institutions in the GCC;

(c) Education and human resource development;

(d) Linkages between elements of the science and technology system;

(e) R and D in the industrial sector;

(f) Information technology and development;

(g) Science and technology indicators in the GCC.

The recommendations of the Conference emphasized the following:

(a) Collaboration among industrial and R and D institutions;

(b) The formulation of S and T policies;

(c) Awareness-building with regard to the role of S and T in today's economy;

(d) Strengthening linkages between elements of the science and technology system.

ESCWA, through its Regional Adviser for Science and Technology, M. Mrayati, contributed a paper to the Conference on the Modalities for Promoting Linkages within S and T Systems.

Calibration and standards in the Gulf countries

The Standardization and Metrology Organization for the GCC Countries (GSMO) held its first meeting in 1984, in pursuance of a resolution of the Supreme Council of the GCCs. The Organization is responsible for preparing, approving and publishing Gulf standards for commodities, products, measuring and calibration instruments, terminology, codes of practice and methods of sampling, inspection, test and calibration. In addition, the Organization assists the member countries in the application of these standards through planning, training, data collection and research studies. In this regard, the twelfth training session was held in Doha, Qatar, on 13 May 1998. The session included a series of presentations on standardization, specifications formulation, quality assurance/quality control, and ISO 9000.

Currently on the Organization's agenda is a project concerned with the issuance of the Gulf quality mark, which will allow commodities holders of this mark to bypass customs.

Collaborating agencies from the Gulf countries include:

- Department of Standards and Metrology, Ministry of Finance and Industry, Abu Dhabi, United Arab Emirates;
- Department of Standards and Metrology, Ministry of Commerce and Agriculture, Bahrain;
- Saudi Arabian Standards Organization, Riyadh, Saudi Arabia;
- General Directorate for Standards and Metrology, Ministry of Commerce and Industry, Muscat, Oman;
- Standards and Measurements and Consumer Protection Department, Ministry of Economy and Commerce, Doha, Qatar;
- Department of Standards and Metrology, Al Safat, Kuwait.

Online education

With the advancement of communications, home learning through the Internet, also called "online education" is becoming a reality. Although the idea is almost 20 years old, its implementation is still under way.

In this regard, an international symposium was held in Tunis in November 1998 on "The future of distance learning in the Arab world". The symposium was organized by the Arab League Educational, Cultural and Scientific Organization (ALECSO). ALECSO was established by the League of Arab States in 1964 to promote and coordinate educational, cultural and scientific activities in the Arab countries.

Major issues addressed at the symposium included the following:

- Evaluation of Arab and international experiences in distance learning;
- Formulation of an Arab strategy and action plan for distance learning;
- New technologies as an infrastructure for distance learning;
- The virtual university: towards an Arab pilot university.

In parallel with the symposium, an exhibition was held to demonstrate new communication technologies, such as video conferencing, and other educational tools.

PART II*

* Articles presented in this part of the Review include excerpts, summaries and full-text versions of contributions made to the ESCWA Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA member countries.

Notes on technology policy and R and D systems in less favoured European regions: research findings and policy implications

By

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United Nations University/Institute for New Technologies

Introduction

The purpose of this presentation is threefold:

- To identify key areas and concepts that have relevance to policy for technology, innovation and competitiveness;
- To present a review of the application of existing ideas and concepts available for policy analysis in four European Union member States (Greece, Ireland, Spain and Portugal) and to examine the value and limitations of these approaches;
- To identify policy issues and concepts that do not appear to be resolvable using current ideas and concepts in the existing technology policy literature.

The theoretical debate

Since the late 1970s, technological change has accelerated in the world economy, bringing fundamental new technologies into widespread use. The new technologies have been accompanied by radical shifts in traditional suppliers of embodied technology in the more traditional industries. The new economic environment is one in which industrializing countries must simultaneously master new technologies and organizational capabilities. For many countries, this new environment is replacing a domestically-oriented technology policy based upon self-reliance and supply-oriented technology policies.

Too often, technology is taken for granted and assumed to be exogenous in the analysis of economics. Similarly, those concerned with the microeconomic theories of industrial organization, innovation and human capital have neglected the macroeconomic environment and how the macro-economy affects technological advances and subsequent economic growth. Most of the literature is taking a positive methodological approach, in the sense that it has been concerned not with policy but with understanding what determines growth and dynamic optimization.

Technology policy can be thought of as a specific set of policies that aim at improving the ability of firms to compete by promoting technological improvements through the generation, diffusion and adoption of process, product and organizational technological changes. In recent years, technology policy has moved to the forefront of the discussion of industrial policy within the European Union members and other advanced countries.

There are many types of policies that come under the heading "Technology Policy". Specifically, policy intervention in technology activities can be classified into three major categories:

(a) Setting up of a legal framework such as a licensing system and copyrights to protect intellectual property;

(b) Government-sponsored R and D and other new technology promotion activities, including the provision of infrastructure and establishing links between research and production;

(c) Direct policies to foster and assist private sector R and D based on various types or subsidies, interest rate reductions, tax reductions and exemptions. A particularly important dimension of such policies in recent years (both in terms of technology policy research and at the level of the implementation of policies) is the issue of associations or cooperation between firms.

In practice, all the above policy instruments are used simultaneously since, to a large extent, they are complementary and in isolation they would not achieve the desirable results. The consensus among economists is that there is a strong rationale for the use of technology policies because investment in R and D or in the adoption of new technologies provides one of the most characteristic cases of market failure in which markets are likely to fail to achieve socially optimal outcomes.

The market failure approach offers only limited guidance concerning the specific problem of the combination and the timing, not to mention the management of policies, in a dynamic context. For example, while the market failure approach directs

[1] Paper contributed to the Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA Member Countries.

attention to the question of whether economic actors are getting the correct incentive signals from markets, a discussion about local firms in less favoured regions is in part the question of what the set of economic actors should be.

Indeed, there is increasing evidence (at the empirical level from the practice of regional development and theoretically in the fields of asymmetric information and endogenous growth) that firms in southern Europe have special difficulties in achieving socially desirable levels of investment. The effectiveness of policy instruments such as tax incentives, skills training and infrastructure provision is limited by the lack of understanding of how firms actually make investment decisions. Investment decisions involve a combination of financial, technological and human resources; of these, financial and technological resources are scarce in poorer regions and must be accessed through Europe-wide markets.

This investment problem has severe consequences at a number of levels. First, these firms are responsible for the greater part of manufacturing, employment and productive skills. If they cannot survive and develop, then the workforce becomes rapidly de-skilled and migrates. Secondly, a thriving regional economy requires a strong network of innovative manufacturing firms which will stimulate further investment in suppliers, services and transport. Thirdly, national industrial strategies in southern Europe are necessarily based on reconversion of inefficient large-scale corporations (often in public ownership) in traditional industrial sectors and the promotion of dynamic and innovative firms in new sectors. To a great extent, such modernization necessarily involves the transfer of technologies for advanced industrial centres, but its adsorption requires considerable managerial and financial resources, while subsequent corporate growth will require endogenous innovation.

The market failure tradition generally provides policy guidance only at a very abstract level. Just as the underlying theory skips entirely over the "soft" parts of organizational capability, it also offers views on property rights, regulations and allocation criteria that are far removed from the local conditions and organizational arrangements that actually produce the need for these institutional "outputs". One illustration of the consequences of this neglect is the enormous time-lag that intervened between academic/theoretical understanding of technology policy as a "market failure" problem and the beginning of serious institutional design and management efforts to implement policy instruments.

A dissonant counterpoint to this shortcoming of overly abstract remedies is provided by examples in which adherence to commonly accepted theoretical assumptions interferes with proper appreciative diagnosis of the problem in the first place. Pioneering work on these lines started 30 years ago. It was part of what is now being called "the appreciative approach to technological change" and started with pioneering work on innovation and technological change at the sectoral level.

Recent work in growth theory has re-emphasized the contribution that investment makes to technological change and thus emphasizes the impact of investment in both physical and human capital on long-term economic growth. This creates a role in the long-run growth process for policies that affect efficiency of resource use, such as coordination of investment decisions and, investment in infrastructure and education as well as the development of science and technology policies.

The challenge of innovation to traditional methods in economics and other social sciences has been a fertile research programme with a broad and diverse collection of theories and empirical research projects, including evolutionary economics and studies of national, regional and sectoral aspects of national systems of innovation. Since the late 1980s, these approaches suggest that research on technology issues should focus on the behaviour of firms (and sectors) in relation to their national institutional contexts. This is an especially important consideration, since nearly all the advances in industrial technology policy have come from an improved understanding of how firms operating in market economies deal with issues of technological change. Policy research on technology issues in relation to industrialization and competitiveness has recently focused on institutional contexts for science and technology at national level. Government policies that are based on a sound understanding of technological innovation and diffusion processes in the private sector create an environment in which these processes can flourish. This is a considerable development of approaches which have up until now focused too narrowly on firm behaviour without exploring the role of institutions and science and technology policies.

The European Union experience

During the 1980s, less favoured southern European regions struggled to find a place in the highly competitive European market that would permit them to continue the transition from traditional agrarian structures to modern manufacturing and service activities. With increasing pressure from advanced European companies and declining demand for traditional labour-intensive products, the modernization of their industries with technology imports and injections of innovative activities in their local technological capabilities became one of the main priorities of industrial policies at the regional, national and European levels.

These difficulties have been exacerbated by the unification of the European market, which has exposed small and medium manufacturing firms to much greater competition in the form of imported products of better quality and lower cost. Short-run profitability has fallen even though new profit opportunities have been opened up, and lower wage costs or local subsidies cannot form the basis for sustainable corporate development. Survival thus requires new investment, initially in competitive process technologies, and eventually in the innovation of differentiated products and new manufacturing methods. Meanwhile the liberalization of the financial sector has tended to both raise real interest rates and reduce the proportion of credit channelled to local production by regional banks, both of which factors constrain manufacturing investment.

The catching-up process made significant progress in southern Europe in the 1980s. Average income grew faster than the EC (European Community) average in Spain and Portugal, but not in Greece. However, the recession in the early 1990s limited the possibility of fast-rising per capita income in the countries concerned. Moreover, recession enhances the risk of slower economic integration and technological modernization as investment is cut back. The upsurge of inward direct investment by EC firms to Portugal and Spain has provided both funds and technology in certain branches, but acquisition is increasingly in services rather than manufacturing, and focuses on larger local companies. Manufacturing firms, in contrast, can suffer from difficulties in competing in modernized product markets and from the reduced capacity of local authorities to intervene in regional economic development.

Technology policy received strong support as one of the structural policies needed to improve the prospects of economic development in southern Europe. Governments supported the development of local technological capabilities with programmes geared to technical assistance to local firms, incentives for FDI, training, and the modernization of infrastructure. Additional funds have been allocated through the EC Structural Funds for the Objective I Regions[1] and from competitive RTD (Research and Technological Development) Framework Programmes.[2] R and D efforts in southern Europe have significantly progressed over the past decade thanks to support provided by EC programmes that have financed more than half of the cost of the R and D infrastructure. With the Third and Fourth Activities of the fourth Framework Programme[3] and Structural Funds for the period 1994-1999, the European Community is putting increasing emphasis on investment in training and research and technology development capabilities in the less favoured regions, with particular emphasis on the problems of local manufacturing firms.

Empirical findings

The integration of less developed regions in the European Union raises the issue of the role of active technology policy in the catching-up process among regions with different levels of socio-economic development.

These policies have been designed around the concept of technological externalities. Recent analyses of industrial development increasingly view this process as dependent on a number of externalities. The experience of dynamic developing economies is increasingly being interpreted as reflecting their ability to close the gap between actual productivity and international best practice productivity. Their ability to reduce this gap reflects both efforts at the firm level and the capability of tapping into technological externalities. The manufacturing sector in less developed European regions, owing to the less developed local infrastructure, was hampered in competition in the European market. What was needed was the provision of technological externalities. These initiatives and the limited restrictions on the intra-European flow of knowledge could facilitate investment at the firm level and the introduction of competitive practices in local industry.

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[1] Objective 1 regions are EU regions whose per capita GDP has amounted to less than 75 per cent of the Community average over the past three years, as well as other regions whose GDP is around that mark. This includes Greece, Portugal, Ireland, and regions of Belgium, Germany, Spain, France, Italy, the Netherlands, the United Kingdom and Austria (*Source*: DGXVI, EC web site).

[2] RTD framework programmes are five-year programmes that cover the EU-funded activities.

[3] The Fourth RTD Framework Progrramme covers the period 1994-1998 and comprises four lines of activity: (a) sustainable growth and employment via technology; (b) globalization; (c) assisting industry to develop new products; and (d) developing creativity (*Source*: WGXXII, EC web site).

This process produced mixed results in different regions owing to the following:

(a) Differences in "demand pull" factors;

(b) The lack of coordination of policies (human resources vs. education policies and/or research vs. on-the-job training);

(c) Differences in the level of institutional efficiency in less developed regions.

What emerges from a comparative study of technology policy, industrial structure and technological accumulation in Ireland, Greece, Portugal and Spain is that it is important to take full advantage of the local provision of technological externalities by local agents as they move towards higher value added activities.

The countries in question have a growth trajectory that has been determined by the import of technology in various forms. It seems that the conditions under which the inflows of technology can be exploited have been changed, and there is an increasing need to introduce matching efforts on the side of the recipient countries. It was also found that macroeconomic policies and the timing of the adjustment processes at the national level exercised a significant influence on corporate performance and innovation dynamics in these countries. For example, exchange rate policies framed corporate decisions on the speed of the modernization of production processes and further on the selection of suppliers of equipment and engineering services.

Implications for policy research

New conceptual and analytical approaches for restructuring technology policy have been developed in both developing and industrialized countries. Many of these approaches appear to have some practical value. Few have been debated or tested thoroughly. There is no widespread consensus about which approaches are the most fruitful or about how to resolve existing conflicts between the approaches. Many of these ideas are still strongly tied to the academic world with limited accessibility to policy analysts.

In order to infuse some practical use into these approaches, it is important to specify clearly the basic characteristics of the country and/or group of countries that relate to local industrial structure and technological activity. In the case of the less developed European Union member States, five issues stand out and provide the "stylized facts" on which we base our understanding of innovation dynamics in these countries and eventually our analysis and proposals on technology policy.

Why do we need technology policy?

1. *European integration, conversion of the manufacturing base and dual industrial structure*

The real challenge in these countries since the mid-1980s has been the conversion of the existing manufacturing base. This process includes conversion within industrial sectors (with technological upgrading and new firms) and investment in new branches. It is obvious, considering the scale of this undertaking, that the introduction of elements of active technology policy will facilitate this process and eventually will prevent numerous systemic failures.

2. *Incentives, subsidies and endogenous capabilities of firms*

What can be seen from the experience of these countries is that, through various mechanisms, a variety of incentives are provided to firms which could support their expansion and improve their efficiency. At the same time, empirical research shows that there is still room for capital-deepening and improvements in productivity in these countries. The main issue for technology policy in this respect is the improvement of firm level capability to integrate available incentives and knowledge flows with credit and emerging market opportunities in a coherent and sustainable corporate strategy.

3. *Macroeconomic trends and firm level decision-making*

A review of many questionnaires and case-studies on factors affecting industrial performance shows that firms are more concerned with the macroeconomic environment than with incentives for innovation and technological development. Considering the characteristics of the local manufacturing base, this trend is to be expected. The lack of resources and short-term strategies of SMEs is the usual interpretation of these research findings.

At a time when the local manufacturing base in southern Europe is facing either a volatile macro-environment with dramatic exchange rate fluctuations due to the current monetary integration challenges, there is room for policies which could support existing technological capabilities, for example, during periods of high interest rates and "downsizing" industrial adjustment processes.

One further rationale for active technology policy in the macroeconomic context of less developed European countries is that one of the few structural policies that have been left with the national Governments in the European Union is the introduction of policies for the improvement of the efficiency of the existing manufacturing base. Investment required for these projects comes from structural funds, which bring additional resources to local policy makers. The introduction of these investment programmes has evident linkages to technology policy decisions and it needs well-founded policy interventions.

4. *Variety: does it matter?*

There are many approaches to variety. Some people say that the most important aspect is the difference in endowments. Others talk about asymmetrical levels of development and the potential of the catching-up effect. Furthermore, there is an approach that argues that variety is also very important in the process of knowledge creation.

Recent research by the European Commission services has raised serious doubts about the trade effects of the economic integration process on less developed European Union regions. The situation on the knowledge creation front is more optimistic. It is clear that less favoured regions went through a significant improvement of their participation in European Commission RTD projects. In addition, some of these collaborative efforts have created well-established links among research partners and the output that has been produced is up to international standards.

Another aspect of variety that has to be addressed by policy makers at some point is the fact that, with the increasing availability of knowledge in the European internal market, there is scope for investment which will facilitate the technology diffusion process. The need for neutral technology policy research is the message that emerges from these remarks.

5. *Systemic failures and the missing parts of the puzzle*

The recent debate on technological accumulation and convergence in southern Europe depends heavily on a simplistic interpretation of the national systems of innovation approach. According to these views, technological development is the outcome of the accumulation of technological capabilities through technology transfer, learning and adaptation of imported technologies to local conditions. Successful local agents respond to exogenous shifts of the technological frontier in the world economy with "best practice" corporate strategies. Virtuous cycles come next, with the accumulation of technological capabilities, exports and technological externalities. The idea underlying this approach is that firms will eventually follow technological trends and that they can mobilize the resources needed for an efficient response to these challenges. However, there is growing concern that we need to move to more realistic hypotheses.

The best way to introduce at least some analytical coherency is to explore further the behaviour of firms investing in new technologies. In general terms, we can argue that successful technological development at the firm level depends on existing capabilities, patterns of development and the macroeconomic environment. Corporate priorities and government policy create the environment needed for the accumulation of technological capabilities. Then path dependency emerges with increasing specialization, contacts and learning assets. Firms equipped with these capabilities compete in foreign markets and cope with the abolition of protection in the local market in developing countries.

The central focus of this approach is the transformation of the local firms, by their acquisition of sufficient technological and financial resources for sustainable corporate growth. The acquisition of technological resources is not a "one-off" event, but rather a continual process of building up engineering capacity specific to the firm, which allows it to adapt technologies for further expansion and integrate these with production and marketing in an effective way. There is evidence that existing technological support programmes for manufacturing firms in southern Europe are somewhat narrow in their focus.

Five additional points summarize the experience of the above-mentioned countries in the actual implementation of technology policies.

(a) *The absorption problem*

R and D spending increased by four to five times (in purchasing power parity in United States dollars) in less than a decade in Greece, Portugal and Spain. The trend was similar in the case of Ireland. A significant increase took place in the case of funding from abroad, which in the case of Greece reached 30 per cent of the local R and D expenditure. The absorption of these resources and the development of new institutions are a major challenge for policy makers. Apart from the execution of the programmes, one important aspect is how lock-in situations can be avoided at the early stages of the expansion phase.

(b) *Policy implementation as a learning process*

The limitations of technology policy instruments in countries lagging behind among the OECD members are well documented in the relevant literature. The same applies in the case of less favoured regions. The policy priorities in the mid-1980s were clearly influenced by the debate on information technologies, new material and biotechnology. However, significant progress had taken place on that front, given the introduction of new and experimental programmes which support technological development in these countries.

The coordination problem is also linked to the incremental accumulation of experience. Fragmented bureaucratic policy-making structures at the national level can thwart the coherence of various policy instruments.

(c) *Institutional and technological externalities*

The role of industrial associations in the process of capturing technological externalities has been referred to by many authors. At the same time, a policy approach that builds on the overall consensus of the social partners and facilitates innovation dynamics with the introduction of new institutions at the sectoral and/or the regional level has been introduced in Ireland, and to some extent in Portugal, and is currently under negotiation in Greece.

(d) *Knowledge and organizational capabilities*

Many researchers argue that, in countries with medium levels of technological development, organizational capabilities play an important role in industrialization and technological upgrading. Different groups of firms, big firms—until recently State-owned local oligopolies—very small firms and medium size firms are in need of these skills. Indeed, this problem needs an integrated technology policy approach in any attempt to solve it.

(e) *Comparative technology policy research*

Many policy instruments have been tried in less favoured regions. The differences in the outcomes of these attempts are an emerging area for empirical research. Why have some institutions and policy initiatives produced certain results in one institutional environment and then completely different results in another? And what might be the relevance of the European experience to industrializing and eastern European countries?

Comparative research could play the role of a selection mechanism. Policy makers could draw upon such expertise for advice and standardized policy instruments.

The R and D tools in Lebanon*

It is with great sadness that we note the passing of the author of this presentation, the late Dr. Hafez Kobeissi, former Secretary General of Lebanon's National Council for Scientific Research. Dr. Kobeissi was a well-known figure in both Arab and European science and technology circles. His eloquence, coupled with a direct and affable nature, contributed in no small measure to the success of many ESCWA, as well as other, regional and international science and technology meetings. Memories of the candid and good-humoured discussions he chaired at these meetings will always be cherished by his numerous friends and admirers.

Introduction

For a country like Lebanon, the R and D "tools" are generally limited to the following:

(a) Institutions of higher education;
(b) Centres of scientific research.

Although, one may need a precise definition of an "institution of higher education" and a "centre of scientific research", we believe that we have first to define "higher education" and to answer the question of what is scientific research.

However, such problems would be the subject of other meetings. Many meetings have already considered these matters in the Arab world, and/or the ESCWA region. Other meetings are needed to evaluate our (Arab) experience in higher education, and to audit our (Arab) scientific research centres.

The aim of this paper is to present the actual situation in Lebanon.

The first modern university in Beirut was founded in 1866. That was the Syrian Evangelic College, known later as the American University of Beirut. A few years later, the French St. Joseph University was founded. It was not until 1951 (a few years after Lebanese independence) that a national Lebanese University was established, and then in 1961 the Beirut Arab University. Currently, Lebanon has about 20 universities; all these are private except the Lebanese University, which is the only public (governmental) university.

For the Scientific Research Centres (SRCs), the situation is different. Lebanon has about 10 centres, all of them public, which were founded after the country gained its independence in 1943. These centres cover activities in agriculture, oceanography, public health, industry, geophysics, atomic energy and renewable energy as well as activities using remote sensing, communications and computing.

The R and D tools in Lebanon are thus limited to these "national" centres, and to four or five universities dealing—to a certain extent—with scientific research.

At the national level, the scientific research has a manager: the National Council for Scientific Research (NCSR). This is a governmental institution, connected directly with the Prime Minister, with relative administrative and financial independence. This scientific research national authority serves the public and private sectors as well. It acts as scientific advisor to the Government, but also as the executive of the Scientific Research Policy approved by the Council of Ministers. It coordinates the national efforts by funding scientific research activities, and by creating national centres when and where needed.

The NCSR will be examined in section I below. The activities of its scientific divisions are also covered. Section II is devoted to the subject of higher education in Lebanon. The activities covered in these sections are reviewed in order to shed light on the role of the different institutions.

I. THE NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

1. *Overview*

The Lebanese National Council for Scientific Research was established in 1962 as the main public institution through which national scientific research programmes are initiated and supported.

Today, the NCSR is the hub of coordination, planning, policy-making, and policy-execution for the scientific community in Lebanon.

Its jurisdiction covers the following areas of exact and natural sciences (fundamental and applied):

Agricultural Sciences
Medical Sciences and Public Health
Engineering Sciences and Technology
Sciences of the Environment
Energy Sciences

* Paper presented at the Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA Member Countries.

Basic Sciences (Chemistry, Physics, Mathematics)
Others

The NCSR is an autonomous public institution under the aegis of the Prime Minister, with advisory and executive functions.

The advisory function involves a variety of responsibilities such as building the infrastructure of the national science and research policy while putting the country's scientific resources to good use.

It also involves initiating proposals to the Government on the promotion of science in Lebanon and centralizing and coordinating ongoing research activities in private and public institutions in the country.

Yet another function of the Council is advising the Government on issues related to science and national science policy.

The executive function involves implementing the national science and research policy designed within the Council's advisory capacity. This policy is approved by the Government in accordance with the economic and social objectives of national planning institutions.

It also involves creating work programmes in cooperation with the related ministries and coordinating them according to the national science and research policy.

In order to reach its goals, the NCSR grants financial aid for advanced studies and research while helping research laboratories in key projects for the development of national resources. It also assigns research personnel to help scientific-research institutions and provides assistance to Lebanese scientists and researchers to attend scientific conferences.

The Council also provides several publications in which local scientific works can be published, and organizes national conferences and symposia with the object of disseminating national and international results of scientific research.

2. *National policy*

The main goal of the national science policy is the development of Lebanon's scientific potential and the use of research results to improve social and economic conditions. The policy also aims to better prepare the economic sector to recognize scientific research as an *instrument* of development and to encourage private investors to contribute to research.

To reach this goal, it was necessary to prepare the intellectual and social arenas wherein researchers can thrive and to ask the Government for cooperation in promising areas of research.

In order to better advise the Government on issues relating to the national science policy, the Council adopted the following four major policy lines in 1996 (as noted in the policy document):

(a) Training qualified personnel to conduct research within the terms of reference of the document. This training will be established and consolidated by the granting of scholarships to deserving candidates, thus enabling them to study for doctoral degrees;

(b) Creating and adopting a "Researcher Status Code" aimed at the institutionalization of scientific research as a career and ultimately as a vocation;

(c) Building a network of individual research projects supported by the Council. In order to optimize the support of individual research projects, the NCSR will consider the following criteria in deciding to grant support to research proposals: priorities, potential scientific contribution, avoidance of duplication of effort, costs, resources, and overall research facilities available or to be made available from other resources;

(d) Establishing the research centres and groups lacking in the country. Some centres will offer logistic support to researchers, including documentation, a geophysics centre, and computer networking universities in Lebanon.

3. *Scientific structure*

Other than the Board and the administrative and financial services, the NCSR operates with seven scientific divisions and seven centres (see boxes 1 and 2).[1]

II. HIGHER EDUCATION IN LEBANON

1. *Overview*

Twenty universities provide higher education in Lebanon. As noted above, the first university in Lebanon, the American University of Beirut, was founded in 1866, followed by St. Joseph University a few years later. All these universities are private, except the Lebanese University founded in 1951, which is official and has branches in all the districts of Lebanon.

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[1] For more information on the NCSR scientific divisions and centres, see E/ESCWA/TECH/1997/WG.1/1/6, which is available at ESCWA, or contact the NCSR

Box 1. The NCSR Scientific Divisions

1. *Division of Agricultural Sciences*

This division provides financial support for research projects presented by researchers working in Lebanon (universities and research institutions). It also implements the Policy and the Five-Year Plan of Scientific Research adopted by the Council.

The following are the types of research projects supported by this division:

(a) Normative projects (following the Five-Year Plan of Scientific Research);

(b) Subjective projects (reflecting the research interests of the researchers).

2. *Division of Basic Sciences*

This division is responsible for all research projects in basic science, including mathematics, physics, chemistry, natural sciences, and computing.

3. *Division of Economical Studies*

This division is concerned with observing economic evolution in Lebanon in order to implement national research and development. Its mission is to identify problems that might be resolved by scientific research.

4. *Division of Energy Sciences*

This division coordinates research activities in the field of energy sciences. It supports research projects in universities and directly supervises the National Renewable Energy Centre (NREC) and the National Atomic Energy Centre (NAEC).

5. *Division of Engineering Sciences and Technology*

This division is establishing and financing a national plan for research and development in engineering sciences and technology. It can also supervise the implementation of such a programme in university laboratories and in research centres. The division also manages the National Centre for Remote Sensing and the National Centre for Geophysics.

6. *Division of Environmental Sciences*

This division deals with the following:

(a) Pollution problems, chemical and biological, in water, land, and air (including noise);

(b) Marine research: pollution, biology, plankton, aquaculture, and physical oceanography;

(c) Industrial waste (gas, liquid, and solid) and household waste (liquid and solid);

(d) Wildlife: animals, birds, plants;

(e) Natural reserves: islands, forests, sites.

7. *Division of Medical Sciences and Public Health*

This division aims at creating a better biological knowledge of the Lebanese population in both normal and pathological aspects, with the objective of measuring precisely the frequency, distribution and severity, as well as particular manifestations of, diseases in Lebanon.

Ascertaining the relative incidences of diseases should lead to improvement of therapeutics, both preventive and curative. Projects are being pursued at three main faculties of medical sciences in Lebanon (Lebanese University, American University of Beirut and St. Joseph University).

Box 2. The NCSR Scientific Centres

1. *National Centre for Scientific Computing*

The NCSR founded the Computing Centre in 1970 to provide researchers with the appropriate accommodations in the following aspects of research:

(a) Project analysis and programming;
(b) Solving computational problems for mathematical and physical research;
(c) Structures calculation;
(d) Calculations related to the drawing up of geophysical maps;
(e) Developing mathematical and digital simulation models;
(f) Analysing statistical surveys.

The Computing Centre was recently strengthened by the installation of a workstation with terminals in a UNIX environment and Internet access.

The NCSR is a founding member of the Lebanese Academic and Research Network (LARN) whose aim is to assure the management of networking and the sharing of information between academic institutions.

2. *National Atomic Energy Centre*

The National Atomic Energy Centre (NAEC) has the following objectives:

(a) Establishing radiation protection infrastructure in the country. The NAEC initiated a personal dosimetry programme (with the help of the IAEA [International Atomic Energy Agency]) and established an inventory of the sources of ionizing radiation material and equipment;

(b) Promoting the peaceful application of atomic energy. The NAEC (with the help of the IAEA) is developing laboratories that deal with the following subjects:

- Environmental analysis (X-ray fluorescence, AAS);
- Food monitoring (Gamma spec);
- Radio-immunoassay;
- Isotope hydrology (with the Litani office);
- Fruit-tree pest (with the Ministry of Agriculture);
- Elisa technique for monitoring livestock diseases (with the Ministry of Agriculture);
- INIS [International Nuclear Information System] centre (for documentation).

3. *National Renewable Energy Centre*

The NCSR was active in the field of renewable energy from 1975 until 1990. During that period, it created the Solar Energy Centre, which was destroyed during the civil strife. Thereafter in 1995, the NCSR created the NREC. Its main activities are as follows:

(a) Building up a solar map and wind map of Lebanon;
(b) Establishing standards for solar heaters of water;
(c) Implementing a pilot project in mini hydroelectricity.

4. *National Centre for Remote Sensing*

The Centre uses scientific knowledge and advanced technology to help in the reconstruction of Lebanon. It plays a pivotal role in contributing to the scientific needs of the country, notably in addressing environmental concerns. The Centre also helps decision makers to take action and set policies regarding safe use of space, remote sensing, and GIS [Geographic Information System].

The following are the Centre's main objectives:

(a) Cooperating with and assisting the public- and private-sector organizations and institutes to plan and implement the use of remote sensing and GIS in their operations, with environmental concerns in mind;

(b) Securing databases from satellite imagery on a timely basis in different areas and disciplines and making the information available to the public and private sectors;

(c) Establishing needed in-house and field support systems, laboratories, and ground truthing for confirmation of sensed data;

(d) Building and training personnel for the Centre as it expands.

(e) Formulating and advising on actions and policies related to conventions, protocols, agreements, or other matters related to remote sensing.

Box 2 *(continued)*

5. *National Centre for Geophysics*

The Centre includes a seismological observatory internationally coded as BHL. Its main objective is to record earthquakes on a continuous basis and to carry out research in seismology.

It produces a monthly seismological bulletin distributed to over 50 observatories worldwide.

The Centre is also interested in magnetometry, gravimetry, and electrical resistivity.

6. *National Centre for Marine Sciences*

The centre's main goals are research, development and education in marine sciences. It provides the following services:

(a) Analytical services;
(b) Bacteriological analyses;
(c) Hydrography.

7. *National Centre for Scientific Documentation*

This Centre was established to strengthen the infrastructure of scientific research. Its main objectives are as follows:

(a) Inventory of national resources in documentation;

(b) Inventory of national scientific production. This involves establishing a library primarily for scientific documents, publications by international organizations, and national publications (theses and unconventional documents).

The Centre has four main activities:

(a) Library;
(b) Documentation services;
(c) National database;
(d) International and national cooperation.

2. *The students*

The total number of students registered in all Lebanese universities was 79,029 in 1994/95. A total of 51.6 per cent were male and 48.4 per cent were female. The student distribution according to university is given in table 2.

More than the half of all the students (52.6 per cent) are enrolled in the Lebanese University. Only nine universities had more than 1,000 students enrolled in 1994/95.

The total number of graduates was 8,209 (table 4). In some tables used here, it is less than 8,209, (precisely 7,990) owing to the non-consideration in those tables of unknown data. The rate of graduation with respect to registered students for some universities is as shown in table 1.

The discrepancy in the graduation rate is due to the circumstances of each university. Some of them have recently increased their activities. Others have low rates, such as the Lebanese University (whose graduation rate is 8 per cent). This is due to the system of the university, which is free of charge.

TABLE 1. THE RATE OF GRADUATION WITH RESPECT TO REGISTERED STUDENTS

Lebanese University	(LU)	8%
Beirut Arab University	(BAU)	11%
St. Joseph University	(SJU)	20%
American University of Beirut	(AUB)	23%
St. Esprit University	(SEU)	8%
Lebanese American University	(LAU)	5%
Notre Dame – Lwayzé University	(NDLU)	13%
Sagesse University	(SU)	4%
Balamand University	(BU)	13%

Table 4 gives the number of graduates who have obtained a *licence* and the number of those who have obtained an applied diploma. The proportion of the students having a *licence* with respect to those having an applied diploma is 3.5.

The tendency in higher education in Lebanon is towards the general and theoretical. Of the postgraduate students in 1994/95, only 219 students (50 of them Ph.D.s) were in humanities faculties.

Table 5 shows the distribution of graduates by specialization and by university. In the humanities faculties, the total number was 5,971 graduates.

We can note the number of graduates in fundamental and applied faculties from table 6. This number was 2,238 graduates.

This demonstrates the above-mentioned tendency to prefer, in general, the humanities to the fundamental or technical sciences.

3. *The teaching staff*

The number of university teaching staff was 7,193 teachers in 1994/95. They were of different grades, including full professors, associated professors and assistant professors. Seventy-five per cent were male and 25 per cent were female. Although women have obtained access to university education, they have not yet obtained a similar degree of access to postgraduate studies. The Lebanese University had 52.6 per cent of students registered in all universities; it had only 47.8 per cent of the teaching staff.

Many members of the teaching staff could have been counted twice or more (those who teach in more than one university). The number of teaching staff is overestimated, particularly in those universities other than the Lebanese University. This will change the figures already given in table 7. The figure of 7,193 teachers in the Lebanese universities overestimates the number of teaching staff. Because the source of the table was not a database having one record per teacher, the table was constructed according to statements from the universities' administrations. This manner of collecting data caused problems in that we could not obtain all the necessary data useful for different analyses, (such as the distribution of teaching staff by specialization and gender, for example).

4. *Academic research*

Only two Lebanese universities (AUB and SJU) publish regular reports on their research activities, so global information on academic research in Lebanon is not easily available.

Yet one can have an approximate idea of the situation by looking at the publications or/and the participation in research conferences. One useful source of information is the yearbook "Lebanese Scientific Abstracts", published regularly by the NCSR since 1993.

This yearbook contains materials communicated by the researchers themselves. The abstracts may summarize papers published in specialized journals, or presented at conferences or similar forums.

The total number of abstracts for 1996 was around 400. The distribution of these abstracts among the universities was as follows:

American University of Beirut	195
Lebanese University	124
Lebanese American University	21
Beirut American University	8
St. Joseph University	5
Others	40

We conclude from the above that academic research in Lebanon was mainly concentrated in the American University of Beirut and the Lebanese University.

TABLE 2. DISTRIBUTION OF THE STUDENTS REGISTERED IN UNIVERSITIES BY UNIVERSITY AND SEX IN 1994/95

University	Males	Females	Total	% Males	% Females	% Total
Lebanese University	19 649	21 946	41 595	47.2	52.8	100
Beirut American University	8 632	4 585	13 217	65.3	34.7	100
St. Joseph University	2 232	3 277	5 509	40.5	59.5	100
American University of Beirut	2 676	2 218	4 894	54.7	45.3	100
St. Esprit University	1 123	1 345	2 468	45.5	54.5	100
Lebanese American University	2 276	1 960	4 236	53.7	46.3	100
Notre Dame - Lwayzé University	1 074	751	1 825	58.8	41.2	100
Sagesse University	737	741	1 478	49.9	50.1	100
Balamand University	649	586	1 235	52.6	47.4	100
Others	1 742	830	2 572	67.7	32.3	100
Total	40 790	38 239	79 029	51.6	48.4	100

Source: Educational Centre for Research and Development.

TABLE 3. DISTRIBUTION OF THE GRADUATES OF UNIVERSITIES BY UNIVERSITY AND SEX IN 1994/95

University	Males	Females	Total	% Males	% Females	% Total
Lebanese University	1 190	2 150	3 340	35.6	64.4	100
Beirut American University	938	518	1 456	64.4	35.6	100
St. Joseph University	435	656	1 091	35.5	60.1	100
American University of Beirut	517	587	1 104	46.8	53.3	100
St. Esprit University	83	104	187	44.4	55.2	100
Lebanese American University	122	89	211	57.8	42.2	100
Notre Dame - Lwayzé University	136	95	231	58.9	41.1	100
Sagesse University	34	29	63	53.9	46.1	100
Balamand University	66	93	159	41.5	58.5	100
Others	73	75	148	49.3	51.7	100
Total	3 534	4 396	7 990	45	55	100

Source: The Lebanese Committee for Educational Sciences.

TABLE 4. DISTRIBUTION OF GRADUATES BY UNIVERSITIES AND DIPLOMAS IN 1994/95

University	Licence	Applied diploma	Higher studies	Ph.D.	Total
Lebanese University	2 804	536	1	16	3 357
Beirut American University	1 456	..	..	..	1 456
St. Joseph University	629	462	19	28	1 138
American University of Beirut	665	439	77	1	1 182
St. Esprit University	110	77	14	2	203
Lebanese American University	150	61	10	..	221
Notre Dame - Lwayzé University	155	76	29	..	260
Sagesse University	63	..	..	..	63
Balamand University	70	89	4	..	163
Others	127	21	15	3	166
Total	6 229	1 761	169	50	8 209

Source: The Lebanese Committee for Educational Sciences.

Note: Two dots (..) indicate that data were not available.

TABLE 5. DISTRIBUTION OF GRADUATES IN LEBANON BY UNIVERSITY AND SPECIALIZATION FOR 1994/95 IN THE HUMANITIES FACULTIES

University	Languages and Literature	History and geography	Philo. and religion	Social sciences	Edu. sciences	Arts	Law and political sciences	Management and economy	Info. and Doc.	Total
Lebanese University	798	448	104	257	43	76	457	232	151	2 566
Beirut Arab University	207	237	209	..	..	..	250	553	..	1 456
St. Joseph University	26	8	1	36	7	6	67	480	27	658
A.U.B	87	14	6	126	79	..	5	142	..	459
St. Esprit	..	..	5	21	11	34	28	61	..	160
Lebanese American University	2	..	..	2	6	14	13	131	3	171
Notre Dame - Lwayzé	1	..	..	..	..	10	5	161	17	194
Sagesse	..	..	..	..	..	..	63	..	..	63
Balamand	29	..	12	..	10	34	..	23	..	108
Others	3	..	71	6	3	..	4	49	..	136
TOTAL	1 153	707	408	448	159	174	892	1 832	198	5 971

Source: The Lebanese Committee for Educational Sciences.

Note: Two dots (..) indicate that data were not available.

TABLE 6. DISTRIBUTION OF GRADUATES BY UNIVERSITY AND SPECIALIZATION FOR 1994/95 IN THE FUNDAMENTAL AND APPLIED SCIENCES FACULTIES

University	Fundamental Sciences	Engineering	Health Sciences	Medical Sciences	Agriculture and Veterinary Medicine	Total
Lebanese University	315	222	125	97	32	791
Beirut American University	..	..	..	..	..	..
St. Joseph University	..	230	55	166	29	480
American University of Beirut	195	262	85	92	89	723
St. Esprit University	..	24	..	..	19	43
Lebanese American University	3	47	..	..	..	50
Notre Dame - Lwayzé University	..	66	..	..	..	66
Sagesse University	..	..	..	..	..	..
Balamand University	..	55	..	..	..	55
Others	9	13	8	..	..	30
TOTAL	522	919	273	355	169	2 238

Source: The Lebanese Committee for Educational Sciences.

Note: Two dots (..) indicate that data were not available.

TABLE 7. DISTRIBUTION OF THE TEACHING STAFF BY UNIVERSITY AND SEX IN 1994/95

University	Males	Females	Total	Males (Percentage)	Females (Percentage)	Total (Percentage)
Lebanese University	2 726	709	3 435	79	21	100
Beirut American University	348	135	483	72	28	100
St. Joseph University	940	432	1 372	69	31	100
American University of Beirut	280	178	458	61	39	100
St. Esprit University	378	92	470	80	20	100
Lebanese American University	104	61	165	68	32	100
Notre Dame - Lwayzé University	106	51	157	68	32	100
Sagesse University	54	6	60	90	10	100
Balamand University	197	102	299	66	34	100
Other	224	55	279	80	20	100
Total	5 370	1 823	7 193	75	25	100

* *Source*: Educational Centre for Research and Development.

Integration of Egypt's National Research Centre in regional R and D activities

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Introduction

In the twilight of the twentieth century, a look at the past 100 years reveals a rich history of unprecedented scientific discovery and technological advancement. From electricity to nuclear fusion and from antibiotics to computers, science and technology played a leading and critical role in raising the standard of living, creating jobs, improving health, and providing national security. Most modern scientific and technological advances owe their origins to research, which is an unlimited source of new knowledge and new applications.

As we move forward into the next century, scientific research will be even more influential in the twenty-first century than it has been in the twentieth century. Research not only produces new knowledge, it deepens and broadens the experience of scientists and engineers who will go on to apply that experience in many creative ways, and who will actually form the strategic human capital for further innovations. Therefore, it is of crucial importance to build up our capacity for problem-solving and creative innovation instead of transferring ready-made solutions.

However, the substantial integration of the global community, GATT and the TRIPS Agreement, as well as the ISO-9000 standards, have ushered in a competitive era in which research organizations must compete on a worldwide level. Moreover, the increased complexity of the new technologies increases the importance of the interdisciplinary programmes. Therefore R and D organizations must respond to the new challenges.

Most of the economies in the ESCWA region are oil-producing economies which rely heavily on oil revenues. Even the economies of the non-oil producing countries in the region are often greatly affected by the volume and flow of oil revenues to the area. These countries are considered big consumers of all kind of technologies despite the fact that their largest investment has been in manpower development. This is, of course, an essential and strategic investment, but for this to bear fruit in the future, integrated collaboration of regional research institutions is mandatory. Inter-institutional networking can then play a major role in building a competitive edge in the global community, with a modest but effective share for each country.

1. National Research Centre (Egypt)

The National Research Centre (NRC) is the largest R and D institution in Egypt. It is a State-owned, ministry-governed body. Upon its establishment in 1956, the NRC was designated to support and carry out research in different areas of science and technology to serve the national economy and respond to priorities established in the overall development plans of the country. These areas were outlined as industry, agriculture, health and the environment.

1.1 *Overview*

1.1.1. *Board of Directors*

The NRC is currently headed by a President with ministerial status, who is assisted by two Vice-Presidents, with vice-ministerial status, one for research and the second for technical affairs, and two undersecretaries, one for presidential affairs, and the second for administrative and financial affairs.

The NRC is governed by a Board of Directors headed by the President. Board members are the two Vice-Presidents, five experienced members in science affairs appointed by the State Minister of Scientific Research, and the heads of the 13 NRC Research Divisions.

The two Undersecretaries of State attend the Board meetings upon invitation. The meetings are headed by the State Minister of Scientific Research, should she or he attend.

The main policies are set by the Board of Directors and followed up by both Vice-Presidents, each in his area of responsibility. Departmental and Divisional councils represent the second stage for implementation of policies at the NRC.

1.1.2. *Research Divisions and Departments*

The NRC consists of 13 divisions and 62 departments. They can be generally grouped as shown in box 1.

1.1.3. *R and D management and offices*

The NRC passed through three evolutionary stages. The initial stage, extending to 1968, concentrated on staff development and building research capacity in basic sciences. The second stage (1968-1973) was characterized by growing interaction with the production and service sectors and efforts to focus research on problems faced in Egypt. During that period, the NRC started to offer its R and D and analytical services to clients against payments. The third stage (1973 up to the present) represents a change from "self-oriented" to "client-oriented" research. Scientists were encouraged to seek contracts with end-users. Committees were formed to assist scientists in establishing this relationship: the Marketing Committee and the Technology Transfer Committee. In 1975, a programming office was established for the first time, to which researchers submitted in-house research proposals for evaluation and financing through the allocated governmental NRC budget. For the first time, the NRC top management could track who was doing what, and this enabled the NRC to direct its capabilities to address clients' needs.

The Technical Office was established in 1987, and was the extension of the previous programming office. It was responsible for the overview of in-house projects financed through the NRC budget, marketing activities as well as for seeking local contracts with clients. International relations were partially supervised directly by the President through the technical office and, when necessary, through the Central Committee for International Relations.

Box 1. The NRC research divisions and departments

Divisions which are oriented towards the industrial sector

1. Textile Industries: 4 departments.
2. Food Industries and Nutrition: 3 departments.
3. Pharmaceutical Industries: 3 departments.
4. Chemical Industires: 6 departments.
5. Applied Organic Chemistry: 2 departments.
6. Applied Inorganic Chemistry: 3 departments.
7. Engineering: 4 departments.

Divisions that are oriented towards the Agricultural Sector:

8. Agriculture and Biology: 11 departments.

Divisions that are oriented towards Health and Environment:

9. Medical Sciences: 6 departments.
10. Environmental Sciences: 3 departments.

Natural and Basic Sciences Divisions:

11. Basic Sciences: 5 departments.
12. Physics: 6 departments.
13. Genetic Engineering and Biotechnology: 6 departments.

In 1993, the R and D management activities were elaborately restructured and three offices were formed: the R and D in-house Projects Office (formerly the programming and technical office), the Marketing and Feasibility Studies Office, and the International Relations Office. In 1997, the first two offices were amalgamated into one office, the R and D Projects and Marketing Office. Together with the Information Centre, the two offices form the core of R and D and technology transfer management at the NRC. Consequently, a Consulting Committee for R and D Management was established, headed by the NRC President and comprising the Vice President for Research, the Vice President for Technical Affairs, the heads of the three R and D management offices and the coordinator of the Information Centre as members. All issues concerning R and D management planning are discussed by this committee, and recommendations are presented to the NRC Board of Directors. The work of the R and D Management Offices is summarized in box 2.

Box 2. R and D Management Offices

Research and Development Projects and Local Marketing Office

1. Focal point for monitoring R and D projects, in-house, local and foreign, starting from application through finalization through specialized committees.
2. Identifying the needs of the local market for services and new products, evaluating the results of applied projects with promising end-users and bringing both together.
3. Consultancy in forming research teams in areas of multidisciplinary projects, local and foreign, with high potential for collaboration with the International Relations Office.
4. Focal point for applications for M.Sc. and Ph.D. degrees.

The International Relations Office

1. Identifying priorities for developing international programmes as a guide for bilateral agreements or scientific collaboration.
2. Providing consultancies to principal investigators of international research projects and activities, and coordination with international funding agencies.
3. Establishing strong links with international sister organizations with mutual research programmes.
4. Establishment of a database on international opportunities, funding organizations and libraries by direct contact or through the use of the Internet.
5. Connecting the NRC with local and international databases of research organizations and libraries through the Internet and preparing a home page for the NRC as a marketing tool.

Box 2 (*continued*)

The Information Centre

1. Establishing a database for researchers, research publications, final projects reports, M.Sc. and Ph.D. theses as well as services conducted by the NRC to help in the marketing activities.

2. Establishing a database for all NRC administrative departments, which—with the databases in 1—will support decision-making for the top management.

3. Issuing booklets on research departments, scientific bulletins, newsletters, collective volumes on publications, M.Sc. and Ph.D. theses and annual reports.

4. Supervision of reports to the mass media, newspapers, radio and television.

The Technical Secretarial Office assists the R and D management offices in carrying out their responsibilities and helps the offices to organize national and international events such as conferences, workshops and meetings.

1.1.4. *Units with specialized status*

In addition to its work on R and D projects, the NRC started offering analysis and consultancy services in 1975. These activities led to the establishment of the so-called Units with Special Status through a Presidential Decree.

According to the Presidential Decree, each unit has its own board which is responsible for planning and decision-making in the unit; each unit is technically, administratively and financially independent of the rigid administrative and financial governmental system.

The units with specialized status are considered the flexible "private sector" of the governmental establishments. They are entirely a customer-oriented system and their services are performed for fees. Currently, 14 units have been established and are functioning at the NRC. The 14 heads of the units, together with the Vice-President for Research, form a collective board for the Units with Special Status.

These units are run by part-time NRC research staff from the appropriate departments, assisted by technical and administrative staff. There is some flexibility with regard to hiring staff from outside the NRC in these units when needed, and agreed incentives are provided according to the task requested. The decision is made by the Board of the Unit.

It is worth noting that the main sectors are the industrial, agricultural, environmental and medical sectors of the country and the region represented in:

(a) Large governmental and public sector enterprises;

(b) Private sector, medium and small enterprises.

The main services offered by these units are consultancy and training services, technological or medical, and analytical services, whether physical, chemical, biological or medical.

Accordingly, the main users of such services are:

(a) The private sector;
(b) Farmers;
(c) Individuals seeking advice on the above subjects.

Currently, 13 units operate with a wide range of diversity in activities. These units are listed in box 3.

1.1.5. *Training Centre*

The NRC houses a training centre, which organizes an annual programme of training courses in various scientific and technological areas and at different levels.

The programme is mainly concerned with the transfer of experience available at the NRC to those who work in sectors of industry, production and services in Egypt, the Arab world and the African continent. Training courses are also offered to researchers and administrators in other research centres and institutes, universities and the public sector.

Box 3. Units with specialized status

1. Central Analytical and Services Laboratory.
2. Textile Industries.
3. Chemical and Pharmaceutical Industries.
4. Drug Technology.
5. Food and Dairy Industries.
6. Medical Services.
7. Consultations and Engineering Development.
8. Agricultural Services and Consultations.
9. Agricultural Experimental Research Station.
10. Technical Services.
11. Technical Consultancy and Project Development.
12. Consultant Unit for Wastewater Management and Environmental Studies.
13. Aquatic Environmental Consultation.
14. Air Pollution Consultation.
15. Air Pollution Protection..
16. Occupational Health and Industrial Medicine Consultations.

The number of courses reaches 160 per year, and the subjects cover most of the scientific and technological fields listed in table 1. These courses are held at the NRC Training Centre during the fiscal year. Several of them are repeated twice or more during the same fiscal year. Some of these courses are highly specialized. Tailoring training courses for a group of trainees is also a common option. The training courses are organized by the NRC for fees from external trainees. A few training courses are funded by donor organizations in collaboration with the NRC.

1.1.6. *Pilot plants and experimental farms*

When first established, the NRC started with a semi-industrial pilot plant. In 1988, a textile pilot plant, built with a donation of the Japanese Government through the Japan International Cooperation Agency (JICA), was set up. A food technology pilot plant was also under construction and was expected to be in operation by late 1995. It was financed by a grant from the United States Agency for International Development (USAID). A pilot plant for micronutrient foliar fertilizers, financed by the German Agency for Technical Cooperation (GTZ), is operating as well as an algae biotechnological semi-pilot unit, financed by the German Federal Ministry for Development and Research (BMBF). The NRC also has a number of experimental farms: one for medicinal plants, a second for agriculture and a third for animal production.

TABLE 1. COURSES OFFERED AT THE TRAINING CENTRE

Health and Environment	21 courses
Renewable Energy and Mechanical Engineering	11 courses
Chemical Industries	25 courses
Food Industries	19 courses
Textile Industries	26 courses
Metallurgy and Metallurgical Industry	2 courses
Pharmaceutical Industries	3 courses
Agriculture and Animal Resources	23 courses
Genetic Engineering and Applied Microbial Genetics enetics	2 courses
Human Genetics	2 courses
Equipment Applications in Scientific, Industrial and Analytical Research	10 courses
Scientific Policy and Project Planning	3 courses
Computers, Software and Hardware	15 courses

1.1.7. *Hardware and other physical characteristics*

The NRC is located in El-Dokki, one of the most distinguished districts in Cairo, directly in the centre of the city. Several hotels of 3- to 5-star quality are located near the NRC.

The NRC occupies a total area of 12 acres divided into two campuses. The original building consists of the central management offices, main conference hall and laboratories. The Chemistry building, Biology building, Physics building, Semi-industrial Pilot Plant, New Conference Centre and utility services are also on the same campus. The second campus houses the major administrative offices, a Training Centre, Solar Energy Department, Micro-Nutrient Fertilizer Pilot Plant, Open Air Semi-Pilot Algae Biotechnology Unit, Textile Pilot Plant, and Food Technology Pilot Plant. The NRC has a fleet of cars for daily errands and visits to factories, and field trips, as well as buses to transport employees to the suburbs.

The majority of NRC equipment is housed within specialized departments. The Central Service Laboratories house the more expensive and general purpose equipment. These include: an electronic microscope, gas chromatography (GC), high pressure liquid chromatography (HPLC), infrared (IR), nuclear magnetic resonance (NMR) and mass spectroscopy (MS). The same laboratories also include physical testing equipment in the areas of ceramics, textiles, polymers and paper and pulp. They are served by a small repair and maintenance unit, which was established through the applied S and T programme financed by USAID in 1976.

1.2. ***Resources***

1.2.1 *Human resources*

The total number of NRC employees is 5,248, out of which 2,466 are research staff. They are assisted by 904 auxiliary staff and 1,878 staff in administrative departments. The research staff is further subdivided into 1,308 Ph.D. holders and their 1,158 assistants, who are supervised by both NRC and university senior staff in preparing their M.Sc. and Ph.D. degrees. The degrees are awarded by the universities (table 2).

1.2.2. *Financial resources*

Government support

The National Research Centre is financed mainly through government funds. The main items in the budget are divided into three chapters. The first chapter covers the wages of the NRC employee and as a rule this is between 70 and 80 per cent of the total budget allocated annually by the Government. The second chapter includes purchasing, services and maintenance, and the third chapter covers replacement of infrastructure, completion of ongoing projects, and development of existing R and D project plans (table 3).

Sources of funds allocated to research are not all governmental. Efforts are being made to increase other funding sources through services from the local, regional and international markets, in the form of tailored R and D activities, consultancies, analytical services and training courses (table 4).

The R and D activities are in the form of project contracts that are either client-oriented, applied research, or basic research in the different research areas of interest.

TABLE 2. ADMINISTRATIVE STAFF IN RELATION TO RESEARCH STAFF
(Various years during the period 1974-1997)

	1974	1980	1985[a]	1990	1995	1997
Research/staff						
Number	1 146	1 306	1 099	1 980	2 373	2 468
Percentage	91.4%	66.5%	27.9%	45.7%	46.9%	47%
Administrative and auxiliary staff						
Number	195	657	2 840	2 351	2 683	2 778
Percentage	8.6%	33.5%	72.1%	54.3%	53.1%	53%
Grand total	1 341	1 963	3 935	4 331	5 056	5 246

a/ After the separation of the Ophthalmology and Electronic Research Institutes, the research staff were transferred to their respective institutes.

TABLE 3. THE DISTRIBUTION OF THE BUDGET OVER A PERIOD OF 10 YEARS
(Millions of Egyptian pounds)

Fiscal year	First chapter	Second chapter	Third chapter	Total
1988/89	13.4	1.8	4.4	19.6
1989/90	16.7	2.6	2.9	22.2
1990/91	18.1	3.0	2.5	23.6
1991/92	20.2	4.5	6.8	31.5
1992/93	24.6	5.3	3.3	33.2
1993/94	34.6	8.5	3.7	46.8
1994/95	40.0	9.8	4.1	53.9
1995/96	44.6	11.6	4.5	60.7
1996/97	52.4	12.0	6.0	70.4
1997/98	61.4	11.9	10.0	83.3

TABLE 4. R AND D EXPENDITURE AND INCOME
(Millions of Egyption pounds)

	1992/93	1993/94	1994/95	1995/96	1996/97
In-house projects[a]	5.2	7.1	7.2	9.6	10.2
Local projects[b]	1.3	1.6	3.8	2.1	2.3
Foreign projects[b]	3.2	4.5	4.3	5.1	2.7
Units with special status[b]	0.7	0.9	1.8	6.9	4.1
Training centre[b]	0.1	0.1	0.1	0.2	0.3

a/ The in-house projects are funded by grants from NRC governmental budget and are expenditures.

b/ The NRC share is 10 per cent of this sum to upgrade the physical and technical infrastructure.

These contracts fall under three categories:

1. In-house contracts, in which the researcher or principal investigator signs a contract with the President of the NRC. This category of contract is fully financed by the NRC, even if it is client-oriented.

2. Local contracts, which are mainly directed towards the production and service sector in the local market. In this category, the end-user signs the contract with the president of the NRC. The Academy of Scientific Research and Technology also contributes by allocating funds to cover contracts between researchers and local end-users.

3. International contracts, which are financed by foreign agencies for conducting joint research between the NRC and a foreign research institute or university.

Consultancy and analytical services are provided by the units with special status. The main end-users of these services are local companies and individuals, as noted obove. The overall income of the units of special status over a period of five consecutive years is presented in table 4. The NRC overhead accounts for 10 per cent of the total income and is spent, according to priorities of the NRC top management, on infrastructure and hardware.

Training courses are conducted by researchers in the different NRC departments and organized and monitored by the *in situ* training centre. The end-users are scientists from Egypt, the NRC, universities and production sectors, as well as other Arab countries and a few former Eastern bloc countries.

1.3. ***Programmes***

1.3.1. *Local level*

Ever since its establishment in 1956, the NRC has been conducting research and development programmes. The NRC originally focused on supporting the national economy and responding to priorities established in Egypt's overall development. The mission has undergone changes, with emphasis on solutions to many of the complicated problems in the areas of environment, water and food supply, energy, health technologies for wealth and job creation, and global quality of life.

An in-house Research Projects Plan (IRPP) was adopted over the years to contribute to national needs. It was decided that the IRPP mandate should be renewed every three years in order to enable the NRC to fulfil its mission.

In accordance with the changes occurring in the international market, the NRC applied an in-house project plan (July 1995 - June 1998) that is mainly development-oriented. Development involves all research activities at the NRC, including development of industrial products, development of agricultural products, development of health and environment measures, and even development of basic sciences.

The current National Research Centre Research Plan is aimed at achieving a greater share of, and more sizeable contribution to, the Egyptian economy through the optimization of the available scientific and technical capabilities of the NRC research staff.

The ultimate goal of research at the NRC is to enhance and improve production in the agricultural, industrial and service sectors of the country.

The Plan is also aimed at improving the quality of the services that meet Egyptian health and environmental needs.

In-house project opportunities

The in-house research projects are grants in the form of contracts to NRC staff for conducting scientific and technological research activities. After careful review of the objectives of the governmental development plan, and in the light of the capabilities and the accumulation of knowledge and scientific experience of the NRC research staff, it was found convenient to categorize the NRC contribution into the following major priorities.

Research programmes of top priority

(a) Development of Agricultural Production;
(b) Environmental Studies of the Sinai;
(c) Environmental Studies for Greater Cairo;
(d) Industrial Development;
(e) Assignment Projects.

The first two areas are aiming at enhancing agricultural products, whether within the Old Valley or in some selected areas in Sinai. There are 20 projects in these two programmes, and they address different aspects of agricultural production.

Agricultural expansion, either vertically by improving productivity or horizontally by reclamation of new lands and introduction of new crops, constitutes the ultimate goal of these programmes.

In the area of environmental pollution, there is one programme with all the projects of an applied nature.

Cairo has been chosen to be a case-study on the high levels of pollution caused by industrial inappropriate waste disposal and air pollution from vehicles and industrial facilities.

Industrial development occupies a prominent place in the ongoing plan, whereby 14 projects have been approved to improve production of the food, chemical, building materials and engineering industries, and to minimize waste and rationalize energy consumption.

The recycling of some industrial wastes is also one of the objectives of these projects.

R and D programmes

These are R and D projects, which are directed towards concrete objectives to serve the production and service sectors of the country.

Preliminary investigations on a semi-industrial bench scale are already available, and require only some upscaling to meet the objectives.

Programme of basic research

In order to maintain the required balance between the capabilities of NRC researchers in both fundamental and applied sciences in different fields of S and T, the NRC administration encourages the funding of a certain number of projects dealing with basic sciences in the fields of agricultural and biological science, microbiology, natural products, health biotechnology, nutrition, organic and inorganic chemistry, earth science, physics and new materials.

M.Sc. and Ph.D. theses also count as a considerable part of this basic research activity.

It is worth noting that the local number of projects is 220. One hundred of these projects are of an applied nature and 120 involve basic research, with prospects of possible application in the future. There were 132 M.Sc. theses and 57 Ph.D. theses awarded in 1996/97.

1.3.2. *Regional and international programme*

Bilateral cooperation programmes have been confined in the past to an exchange of visits. This is changing, as both sides request a more concrete relationship based on projects of mutual benefit. This is apparent in bilateral cooperation with Italy, Germany (through BMBF) and the United Kingdom (through the Higher Education Scheme). These cooperation programmes require financing by both sides. This category of programmes provides for the local scientists to be on a competitive level with their international counterparts. It is expected, over the next few years, that this will be the general trend to ensure proper transfer of knowledge and technologies.

Another important programme is the Egyptian-United States partnership programme, via the Science and Technology Agreement, whereby the NRC plays a major role as a coordinating site, as Technical Agent, for manufacturing technologies. It is anticipated that more assignments will be allocated to the NRC in the next phases of the agreement.

2. Towards better integration of regional collaboration and networking

In the light of the current international changes, and because economic, scientific and technological activities have rapidly expanded to a global scale, we are starting to realize that our earth is not infinite, but limited. The limitations are becoming more and more apparent in many areas, including natural resources, energy and markets. We are facing serious challenges, especially as developing countries, to find ways and means of achieving a "sustainable development" that recognizes the intrinsic and fundamental limitations. Great expectations are placed on the prospects of future development in science and technology and its proper utilization to secure a balanced and just sustainable development among all countries.

The international scientific society is heavily engaged in multinational research programmes that are proposed and administered by developed countries. These programmes involve the National Science Foundation and the National Research Council of the United States, the European Commission (for Europe and the Middle East), and the Japan International Cooperation Agency.

The participation of scientists from third world countries in these activities does not directly benefit their societies, as these research programmes are tailored according to the priorities set by the developed countries. The time has come to establish a framework to initiate scientific collaboration between developing countries in the field of research and development.

The reasons given by developed countries in support of the employment of scientists from third world countries are the following:

1. To develop new technologies touched off by different conceptions (ingenuity of different ethnic societies);
2. To globalize research management;
3. To reinforce manpower (highly qualified scientists);
4. To select excellent foreign researchers;
5. To establish the infrastructure for current and future expansion of overseas multinational facilities;
6. To secure the hegemony of the Western-led research programmes on a worldwide scale.

Before examining the NRC contribution, some important issues need to be addressed, identified, and discussed on a national as well as regional level.

2.1 The need for collaboration in R and D on regional and international levels

As S and T advance, they require everlasting resources in terms of research facilities, expenditure and qualified researchers. The tremendous magnitude of these investments in "megascience" now makes regional and international cooperation essential. Examples are space exploration and nuclear fusion programmes. For our region, the adoption of megascience in the fields of energy and natural resources is justifiable. The ESCWA member countries should be encouraged to establish R and D networks between their research institutions as a prelude to the establishment of regional megascience programmes for areas of common interest.

Countries such as the United States, Germany, France, the United Kingdom and Japan are increasing investment in research and development to generate new knowledge and technologies. This enables them to be a driving force and empowers them to control the world economy, benefiting from the new international trade and commerce regulations.

At the same time, it is worth noting that the ESCWA member countries are investing sizeable financial and human resources to build R and D infrastructure and capabilities. The current individual country investments will always be considered low if compared with what is spent by the developed industrial countries.

Therefore, integration is the optimum and most feasible action for the ESCWA member countries to enhance and complement one another to boost their economies.

Regional cooperation in research and development between our nations is becoming a matter of life and death. The exploitation of natural resources within our boundaries in a more rational and economical way should be our responsibility. The creation and adoption of national and regional research programmes, funded equally by the participating countries, would furnish the basis for the promotion of S and T as the driving force for the "sustainable development" of the ESCWA members, which are entitled to lead this initiative with their existing human capital of scientists and the more or less favourable infrastructure in the 13 members.

The NRC, well aware of the above, established in the late 1980s the technical office of the NRC to assist the President in administering and managing R and D activities. Later, in the early 1990s, this body was restructured into an R and D management framework in support of research projects, marketing and feasibility studies, and the international relations office. In view of the experience of the past few years, a cosmetic reshuffling was recently undertaken, and the R and D management activities are being administered under the umbrella of two offices: the research projects and local marketing office; and the international relations office.

These changes are the result of a continuous assessment of our performance, which covers several parameters, including:

(a) The revenues from research projects funded either locally or from foreign and international agencies;

(b) The revenues from services, consultancies and training activities, and the competitive capabilities of our scientists to obtain funding from local and foreign donor agencies;

(c) The number of publications co-authored with foreign researchers and the number of citations in papers from abroad.

2.2. Prominent reasons for limited success or failure

Before enumerating some proposals for optimizing collaborative R and D activities and networking between the ESCWA member countries, we should point out some prominent factors and reasons for failure or delay of the collaboration, to be taken into consideration in discussing future collaborative plans and steps for achieving an optimized regional scientific R and D network. Some of these factors are:

(a) Absence of a regional S and T strategic policy;

(b) Lack of confidence in regional human scientific capabilities;

(c) Absence of specialized R and D management structures;

(d) Inadequate regional networking for information and communication.

2.3. Regional future vision, objectives and development plan

The NRC, as one of the largest R and D institutions in the Middle East, can and should play a major leading role in enhancing and strengthening R and D inter-institutional collaboration and networking.

In order to optimize the role of the NRC and other R and D institutes in the ESCWA region, the vision, objectives and future plans for collaboration need to be identified.

Vision

The ESCWA member countries should have the main policy orientations of a development plan for the coming 5-10 years. This plan should focus on bringing the economy to an international level; this would require the development of a competitive society characterized by a high innovative capacity and a dynamic productive sector. Equally important is the need to ensure equitable and sustainable development in the region, based on social participation, equitable distribution of the benefits of development and a rational preservation and use of its natural resources. There should also be a conviction that knowledge generation and the capacity to use and apply knowledge are basic to the success of sustainable development.

Objectives

Our policy should aim at developing and strengthening the capacity to carry out research and to generate and use knowledge, with the objectives of increasing the competitiveness of the productive sectors, ensuring sustainable use of the region's biodiversity and natural resources, and promoting the well-being of the population. These general objectives, can be further spelled out in terms of the following specific objectives, which should be submitted for discussion between the ESCWA member countries:

(a) Fostering scientific research and generating knowledge through the support of research projects and research centres, seeking to consolidate regional research groups and research networks in the basic sciences;

(b) Increasing the size and quality of the scientific community through training and development of human resources;

(c) Developing and supporting research on the natural resources in the region. This includes the development of new appropriate technologies, as well as research on production systems adequate for social and environmental needs;

(d) Carrying out regional scientific and technological activities to respond to the various needs and requirements of the different member countries;

(e) Integrating science and technology into the regional society and culture;

(f) Facilitating access to scientific and technological information, as well as the application and use of new information technologies. This entails strengthening the participation in the Internet and specialized international information systems and networks;

(g) Integrating the regional scientific community into the global scientific community, through facilitating interaction with research groups in other countries and participation in transnational research and innovation networks;

(h) Supporting the development of social sciences, seeking a greater degree of consensus and equity in the context of the region's cultural diversity.

Developmental plan

In order to formulate a regional development plan, a series of meetings should be held between the ESCWA member countries in the forum of a Steering Committee to identify the various programmes constituting the plan.

Funding mechanisms and individual institutional developmental efforts for the programmes also need to be discussed. The plan should eventually lead to the fulfilment of the regional objectives. In brief, some of the programmes to be carried out should cover the following topics and given priorities:

(a) Development of human resources;

(b) Strengthening research as well as its relationship to development;

(c) Information exchange policy;

(d) Internationalization of science and technology.

2.4. *NRC potential*

The NRC has great potential to play a major role in networks, including R and D institutions in the Arab countries. This is partly because of certain physical characteristics but, more important, because of its experience acquired over the years.

2.4.1. *The general factors that increase the potential of the NRC* are as follows:

(a) The central location in Egypt as well as in the region;

(b) High quality personnel;

(c) High quality performance;

(d) Presence of a provisional market;

(e) Access to a good library service (NIDOC);

(f) Coordinated research activity inside and outside the NRC;

(g) Recognition and support of the authorities.

The scope and range of activity conducted at the NRC are diverse. Some particular specializations achieved excellence owing to common criteria that were met and emerging demands that helped to develop particular areas.

2.4.2. *The specializations* that met these criteria and that are recognized as centres of excellence by the TWAS (Third World Academy of Sciences) members are listed below (table 5).

(a) The environmental pollution research technologies at the NRC, especially with regard to water, are recognized locally, regionally and internationally as all the stipulated criteria were met, in addition to one very important factor, which is the emerging demand for theses and research at the global level. This paved the way for local, regional and international funds to be allocated to this research area.

(b) Egypt is considered one of the most important countries in exporting medicinal plants, especially to Europe and the surrounding regions. More than 2,000 species of medicinal and aromatic plants grow in the Egyptian desert, which has created a base of raw materials for phytochemical research. The most promising species of medicinal plants as regards experimental cultivation have been introduced into production, leading to an increase in the economic effectiveness of the herbal industry. Research carried out in Egypt has focused mainly on the chemical composition of extracts from these plants. In most cases, this work was not complemented by pharmacological and clinical trials to confirm the claims recorded in the traditional systems of medicine, except in a few examples.

(c) Among the different multidisciplinary research areas at the NRC, the field of applied microbiology and industrial fermentation is well established as it has received much attention since the establishment of the NRC. The research teams have contributed significantly to the advancement of applied microbiology and industrial fermentation during the past 30 years. Examples of their contributions are: microbial steroid transformations, alkaloids, antibiotics, enzymes, single cell protein production, other secondary metabolites, organic acids and solvents and amino acids.

(d) Glass, ceramic and building materials were first used in the Egyptian region 7,000 years ago; raw materials are available in large quantities in Egypt. Research activities in this area started at the NRC upon its establishment in 1956. Since then, unique specializations not available in other research institutes or universities were established.

TABLE 5. NUMBER OF RESEARCH STAFF IN NRC CENTRES OF EXCELLENCE

Staff / Division	Water pollution	Fermentation industries	Natural products	Glass, ceramics and building materials
Emeritus Res. Prof.	2	10	2	3
Research Prof.	12	20	24	28
Assist. Res. Prof.	8	20	12	2
Researcher	5	30	18	3
Assist. Researcher	11	30	23	8
Research Assist.	5	40	12	4
Total	42	150	91	47

2.4.3. *Central analysis and service laboratories and units with specialized status*

The Central Analysis and Service Laboratories (CASL), one of the units with specialized status at the NRC, were established in 1978. Their establishment is considered an important milestone, as it was to help to fulfil the mission of the NRC, which is to conduct basic and applied research to serve developing agriculture, industry, environment and health on a national level. Thus, the CASL were established to provide analytical services to support scientific research activities and the application of recent and up-to-date technologies in both the scientific and production sectors.

The CASL include two main laboratories:

(a) The Central Service Laboratory, which comprises the following units: Infrared, Mass Spectrometry, Nuclear Magnetic Resonance, Atomic Absorption and Ultraviolet, Microanalysis, X-ray, Electron Microscopy, GLC (gas-liquid chromatography), and Thermal Analysis.

(b) The Material Testing Laboratory, which comprises the following units: Ceramics, Polymers and Solid Materials, Textile and Paper, Pharmaceutical, Isotopes, ESCA, and Biological Fluids.

The CASL are considered an important cornerstone for the NRC in-house projects as they provide the required analyses for many of the projects run by staff members in the different research departments. M.Sc. and Ph.D. candidates rely heavily on the availability of modern and sophisticated equipment to complete their research work; they know that they can obtain accurate data with a high degree of precision and accuracy. The CASL are not only needed by NRC staff and students, but their reputation extends to universities and other research centres as well as production sectors, public and private, ministries and national projects and enterprises.

All 16 units with specialized status are assigned R and D activities, each in its own specialty. Their objectives can be summarized as follows:

(a) To provide accurate and precise results and data for products and materials whether solid, liquid, or gaseous, inorganic or organic, biological, natural or artificial;

(b) By relying on the highly trained personnel and available up-to-date equipment, enabling some of the Units with specialized status to function as reference laboratories;

(c) To develop and establish standardized values for industrial and semi-industrial products such as natural products, organic and inorganic, pharmaceutical, ceramic, textiles and other materials;

(d) To provide training to university and research centre staff members as well as to staff and technical assistants in R and D units affiliated to different industries and ministries.

Potential for success of the units

(a) The presence of highly trained experienced NRC staff members (Ph.D. holders and their assistants) as well as trained technical assistants;

(b) The high quality personnel, the up-to-date equipment and the central location of the NRC constitute an important potential and are big assets in providing training to universities, staff of research centres, and production sector personnel;

(c) The already existing linkages between universities, research centres and production sectors, both public and private;

(d) The high performance analysis equipment available.

2.4.4. *Major scientific achievements*
Environment

(a) Technology of drinking water treatment in Greater Cairo;

(b) Air pollution control and prevention for Greater Cairo, Alexandria and Suez;

(c) Wastewater assessment, management and minimization for Kafr-El-Zayat and Shubra El-Kheima cities, and 24 projects and factories.

Textile industries

(a) Upgrading of sizing materials from local materials;

(b) Recovery of the soluble sizing materials from wastewaters to improve their environmental character.

Chemical industries

(a) Development of marine antifouling paints [Navy];

(b) Development of local hot thermoplastic traffic paints [Ministry of Transportation];

(c) Deposit rocks as a substitute for asbestos in PVC tiles [Canaltex Company];

(d) Anti-corrosive compounds for protection of boilers and metallic pipelines [El-Suez Petroleum Company and other companies];

(e) Improvement of ethanol and fodder yeast production with increases of 30 and 50 per cent respectively [Sugar and Integrated Industries Company].

New contracts with the same company

(a) Production of pentosane polysulfate from sugar cane by-products;

(b) Fermentation production of citric acid from molasses;

(c) Local production of magnesite refractories increase of 8 million Egyptian pounds (LE)/annum [Egyptian Refractories Co.];

(d) Production of inorganic and intermediate chemicals: 11 compounds were prepared at an estimated savings of LE 150/annum [El-Nasr Pharmaceutical & Chemical Company].

Pharmaceutical industries

Production of 26 starting compounds from local materials. Calculated savings amount to LE 220/annum [El Nasr Chemical Company].

Agriculture

(a) Development of tomato production in an area of 1,000 acres with a calculated increase in production of LE 48 million (1985-1986);

(b) Development of corn production in an area of 100,000 acres with a calculated increase in production of LE 5.6 million (1985-1986);

(c) Development of sorghum production in an area of 80,000 acres with a calculated increase in production of LE 21 million (1993);

(d) Governorates: Giza, Fayum, Asyut, Sohag, Quna and Aswan;

(e) Utilization of sulphur in improving the quality of reclaimed lands; this led to an increase in production of several crops by 30 to 250 per cent [Kafr-El-Zayat Company];

(f) Optimization of micronutrient fertilizers, a service offered to farmers in over 10 Governorates, with a calculated increase in production of LE 4 million.

Rural Development in two villages, Atris and El-Katta, in El-Giza Governorate

(a) Increase in production of several crops;
(b) Improvement in health services;
(c) Introduction of some cottage industries.

Food industries

(a) Introduction of ultra-filtration in the cheese industry, with a calculated increase in production of LE 12 million [Misr Dairy Company];

(b) Production of natural colorants [United Chemical Company];

(c) Development of waste products from glucose and starch processing for use in the textile industry and in soil improvement, with a calculated annual increase in production of LE 4-6 million [Egyptian Starch and Glucose Company].

Engineering

(a) Design of local units for biogas production from organic wastes;

(b) Process development of some chemical industries;

(c) Water desalination activities;

(d) Municipal solid waste management;

(e) Studies and basic engineering of industrial pollution: Prevention Treatment Systems.

Health

(a) Genetic mapping and counselling;
(b) Prevention of nutritional diseases;
(c) Basic medical research.

2.4.5. *Relations with other institutes*

On the national level

Collaboration between the NRC and other institutes is coordinated through the Supreme Council for Research and Institutes. Collaboration is also carried out on an individual level through collaboration within research projects. The Academy for Scientific Research and Technology (ASRT) also forms one of the major sources for research funding, through its Research Councils that allocate funds for projects on a national level. Collaboration is being further optimized through the exchange of visits and collaborative projects, which are being encouraged. One of the most productive relations with ministries is that with the Ministry of Agriculture and the Ministry of Health, through which many collaborative R and D projects are implemented by NRC staff and financed by the respective ministries. A number of projects are currently being prepared under the MERC programme with the Ministry of Agriculture.

On the regional and international level

Bilateral cooperation programmes have been confined over the past to the exchange of visits. This is changing, as both sides request a more concrete relationship based on projects of mutual benefit. This is apparent in bilateral cooperation with Italy, which only considers projects financed by both sides. It is expected that over the next few years this will be the general trend to ensure that cooperation will lead to the transfer of knowledge and new technologies.

Bilateral cooperation with developing countries needs to be better developed. Scientists' exchanges must be on a larger scale, and the scientists must work together for longer periods on projects with well-defined objectives. International organizations affiliated to the United Nations have played a major role over the past few years. This needs to be better developed to optimize the use of available grants.

2.4.6. *Plans for upgrading the NRC up to the year 2002*

Ever since its establishment, the NRC had conducted basic scientific research and technical training. This shifted to a client or end-user orientation, and finally to a development orientation, which was the result of the continuous development process that is occurring at the NRC. The NRC mission shifted in orientation owing to a number of factors:

(a) Changes in affiliation and spontaneous organizational restructuring;

(b) Establishment of a number of independent research institutes (five) that were originally divisions at the NRC. Two are in the area of health and three are related to industry;

(c) Adoption of a university-type system in structure of departments, promotions and oriented research.

With these factors in mind, and taking into consideration GATT, ISO-9000 and the TRIPS Agreement, it becomes inevitable that the mission of the NRC should be reconsidered, revised and reformulated.

The revised mission statement for the next 10 years is to make the NRC an internationally recognized multidisciplinary institute of unique and high quality performance.

To redefine the mission of the NRC, studies have been conducted on the following:

(a) Outlining the national plan for S and T based on the economic reform plan. Although this is the role of the Ministry, the NRC could play a role in setting this goal through its experts in different areas who should be involved;

(b) Market study in Egypt and the region;

(c) Information on new international developments in the fields of interest.

A plan for implementing the mission has been set. Its broad outlines can be summarized in the following:

(a) More involvement with end-users in decision-making should take place in Advisory Boards in various research areas. This will strengthen the links between the R and D activities at the NRC and its various end-users;

(b) Restructuring of department and divisions to optimize and enhance the implementation of the mission. The NRC has already initiated a restructuring plan. The first step was a questionnaire, the findings of which will be presented at a symposium and the results presented to the Board of Directors for ratification. The second step will be the identification of the research priorities, future outlook and new frontier areas by each division (and departments). These priorities will help the top management to set a policy for R and D. This will also take into account the role of marketing as defined below;

(c) Stress is to be placed on marketing (as part of an overall R and D management system). The role of marketing should be:

(i) To concentrate on successful areas of R and D to create a database of commercialization records to be used in optimizing present and new areas;

(ii) To focus on multidisciplinary national problems;

(iii) To study the TRIPS Agreement to select projects for cooperation with foreign and local firms operating in the country;

(iv) To adopt innovative reverse technology based on market needs;

(v) To focus on creating new trends and scientific frontiers;

(vi) To concentrate on major issues such as:

a. Environment: clean technologies, treatment or recycling of wastes;

b. Non-conventional energy;

c. Biotechnology;

d. New material;

e. Total management systems in specific industrial areas to implement ISO 9000.

This strategic plan for NRC development and restructuring should enable the NRC to play a major role in the integration of regional R and D activities. It is the first time that the NRC management has realized the importance of a dynamic plan that would offer flexibility in the mechanisms of implementation, whenever global changes take place. In this way, the dynamic mechanism will allow the possibility of continuous institutional development that can cope with rapid international changes.

2.5. *Role of the NRC in enhancing inter-institutional R and D collaboration and networking*

2.5.1. *Networking through the Internet*

Information is one of the main ingredients of social, economic and cultural revolution. In the globalized information world of today, the capacity to obtain and use information is one of the main differences between rich and poor countries. This has a direct impact on how knowledge is used to solve problems, to train human resources, and to obtain competitive advantages.

Egypt is undergoing a wave of restructuring, developing and upgrading in many of the science and technology activities in universities, research centres and institutes as well as in production sectors, public and private. A central feature of the restructuring is the introduction of modern communications in the infrastructure of the organizations. There is an urgent need for this sector to expand and liberalize.

The NRC, as a State-owned research centre, needs to make a big jump into the modern world of science and technology; its only option is to get connected to the Internet to make this jump. Much effort has been expended to achieve this goal, even within the very limited resources of the Centre. The Internet will allow the NRC to access easily any database, whether national (especially private production companies), regional or international. Furthermore, a web site for the NRC on the Internet will allow wide propagation of information about the NRC, and this could be an international marketing tool.

The NRC will then be in a position to shoulder some of the responsibilities for developing a regional information and communication facility. The NRC can function as a regional node for academic and scientific institutions in the region and play a leading role in:

(a) Formulating a regional information policy;

(b) Establishing and strengthening regional scientific and technological information systems;

(c) Organizing information services with the capacity to provide access to national or international sources in specific areas of knowledge;

(d) Establishing a regional information network among scientific and technological institutions in the region, in order to build a telecommunication backbone to connect regional and national databases so as to provide access to international information resources through the Internet.

2.5.2. *Industry-oriented research*

The introduction of the GATT, the WTO and the application of ISO 9000 in manufacturing, in addition to the new strategies pursued by multinationals, will put a premium on cost reduction, flexibility in product mix and equipment, and higher quality.

While public institutions will continue to play an important role in supporting growth and development in Egypt, they are committed under the new policy to channel their services to support this important privatization initiative.

Recent experience indicates a new openness in this sphere, stemming from the need of the industrial, commercial and service sectors to address technological problems, and to improve productivity, competitiveness, and quality. Thus, there is a newly created demand for developmental and applied research oriented to the new free-market economic system. A number of State-owned industrial facilities have taken the initiative by establishing close cooperation with R and D institutions to face the new challenges at both the domestic and the international levels.

On the regional level, there is a growing need to upgrade the areas of excellence at the NRC in order to form a driving force for the whole region, as the problems faced are more or less the same in the other Arab countries. This scientific union would support the whole region economically and would narrow the technological gap.

In the late 1980s, huge advances were made in research activities owing to the introduction of new technological advances in information and communication. Access to the Internet and e-mail overcame almost all geographical, political and time barriers between researchers, research institutes and even production sectors. This has been reflected in the form of the international agreements for trade and standardization.

On the national level, the increasing pollution of the environment due to industrial waste directed the attention of the NRC researchers to the importance of starting programmes to handle industrial liquid and solid waste disposal. The water pollution problem is not confined to Egypt but applies to all countries, and therefore it had to be considered a priority for researchers all over the world.

The NRC can also play a major leading role in the following research areas related to industry.

Chemical industries

This category has the largest number of NRC contracts with industry. It comprises glass, building materials, polymers, paper and pulp, and pesticide chemistry. The fertilizer industry also constitutes a major part of chemical industry activities.

The projects undertaken are mainly designed to assist major public companies with regard to major products and to stimulate the process of development.

Pharmaceutical industries

This area has established relatively good contacts with clients directly. The natural product research has been enhanced and integrated with the pharmaceutical industry.

Textile industries

The clients in this category are mainly big public sector companies, which rely on NRC staff in their R and D activity.

Food industries

Projects financed by clients are few when compared with the currently large number of private investments in this industry on the national level.

Several other promising examples can be noted in the fermentation industries and in occupational health. Their success relies mainly on their cooperation with private rather than public sector enterprises.

2.5.3. *Suggested areas for the role of the NRC in regional R and D projects*

(a) Management of wastewater treatment in various industrial facilities, such as textile, paper and leather operations;

(b) Oxidizing destruction of organic compounds in diluted water solution by ozone;

(c) Development studies for a solar-operated small-size humidification-dehumidification water desalination unit;

(d) Multi-purpose pilot facility;

(e) Water-borne corrosion inhibitors for surface coatings;

(f) Advanced ceramics for application in severe environments;

(g) Environmental protection technologies: molecular modelling in the design of crop protection chemicals;

(h) Fermentation industries such as:

(i) Utilization of Egyptian cotton stalks to produce liquid fuel (ethanol), sweetener (fructose) and adhesive lignin;

(ii) Structure elucidation of phenolic and flavonoid constituents of some members of the Labiateae and the Leguminosae and their biological activity;

(iii) Efficient production of butanol and acetone in FED-BATCH extractive and continuous immobilized bed fermentors using different strains of Clostridium Acetabutylicum and selective membranes.

These are either completed or ongoing research and technological applications, with the end results being expansion to an industrial scale by a local or regional end-user.

Views from Kuwait on the promotion of R and D activities in the ESCWA member countries

The following paragraphs are excerpts from a presentation made by Yousef Al-Sultan, Deputy Director General of the Kuwait Institute for Scientific Research (KISR), and Ahmad Ghosn, also with KISR. The presentation was made at the 1997 Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA Member Countries. The excerpts below outline the capabilities and research interests of KISR, which is Kuwait's foremost research organization.

KISR capabilities and past accomplishments/experiences

Over the last three decades, KISR completed the establishment of its scientific infrastructure, and trained specialized cadres of qualified researchers. KISR current and future plans involve a leading and progressive role by the Institute in promoting science and technology in fast-developing Kuwait and importing advanced technologies from leading research centres around the world.

KISR plans are geared to integrating R and D outputs with national economic and human development. These plans are also designed to project the role of KISR in society, benefit from the Offset Programme and redistribute research-funding sources according to priorities. To achieve all the above, it is necessary to set up an integrated system to back up internal and external communication at KISR and to enhance its R and D impact on the national and regional levels.

On a local level, it is expected that increased efforts will be made to privatize government institutions, some of which are currently clients for KISR. Such efforts will also focus on the need to carry out studies on how to reduce project cost and maximize the efficiency of scientific R and D output. It is also expected that KISR will have more opportunities to enter into Offset Programme projects, which would help it to overcome current financial difficulties.

On an international level, it is expected that information technologies will have an increasing impact on research activities, as more integrated information systems are expected to emerge (audio, video and motion). Moreover, it is expected that biological techniques will be adapted for use in plant and animal production and aquaculture. Similarly, industrial techniques are expected to be adapted for use in oil and water treatment fields. KISR plans to adopt and enhance the use of these techniques to achieve optimal resource development and R and D socio-economic impact.

KISR research programmes

There are six research programmes at KISR listed below, in addition to well-established technical and administrative-support infrastructures:

Food and Biological Resources
Water Resources
Environmental and Earth Science
Support of Oil Sector
Engineering Systems
Techno-economics

A summary of the goals and objectives of each of the above research programmes is contained in the following sections.

Food and Biological Resources Programme

Research activities in this Programme focus on increasing production of natural resource to achieve acceptable world standards in food production, consumption, handling, storage and conservation. The Food Resources Division is also concerned with improving living standards, enhancing the desert environment, developing national cadres, and encouraging private sector investment in aquaculture, landscaping and agriculture. The Programme is also concerned with the applications of genetic engineering, tissue culture and industrial fermentation, and bio-remediation of the polluted environment in relation to the impact on food resources.

This Programme consists of the following elements: arid land agriculture; mariculture and fisheries; biotechnology; and food technology

Water Resources Programme

Research at the Water Resources Division is specifically concerned with post-treatment wastewater utilization techniques, protection of subsurface water from contamination, development of water desalination techniques and more convenient alternatives, development of subsurface water reinjection techniques, finding solutions to the rise of subsurface water levels in certain areas, setting up a special programme to rationalize water consumption, and qualification of national cadres in water resources management. The Programme comprises: hydrology, desalination, wastewater treatment and water management elements.

Environmental and Earth Science Programme

Research in this Programme is concerned with marine oil pollution in general. It involves coastal and baseline environmental studies, covering pollution caused by burning natural gas and waste matter, and by the discharge of liquid and solid municipal waste in urbanized communities and, finally, the nature of the desert and the effects of sand transport on civil and military installations. This Programme includes environmental science and management, desertification and aerodynamics, and hydraulics and coastal engineering elements.

Oil Sector Support Programme

This Programme continues to pursue the objectives outlined in the Transitional Strategic Programme, which include providing support to the oil sector in the field of research and development, and working to achieve specified targets stated in the Fourth Strategic Programme, including continuing to develop technical labour, equip special labs in modular production plants, produce and refine oil, solve corrosion problems, draw up needed policies to introduce the Programme into oil sector activities, respond to its needs, and maintain its scientific level by arranging symposia and conferences, and publishing in scientific magazines. The Programme comprises four elements: oil production, oil refining, polymers and petrochemicals, and corrosion

Engineering Systems Programme

This Programme seeks to identify advanced technological applications to achieve better utilization of natural, human and financial resources in the Kuwaiti economy, through contributing to the development of an Energy Utilization Plan, the identification and development of energy supply sources, assistance in the transfer of oil and petrochemical refining control technologies, development of industrial and building construction and maintenance systems, and utilization of advanced technologies in improving general safety conditions and the environment. This Programme comprises the following three elements: energy, building technologies, and systems and control

Techno-economics Programme

The Programme provides support for local institutions in the field of economic analyses, assists decision makers in setting up priorities, distributes funding from sources, provides needed criteria and advice for industrial development and supports the needs of other research programmes in the techno-economic field. The Programme consists of two elements: economic studies and decision-making science.

KISR available R and D infrastructures/resources

Manpower

KISR has very qualified technical staff in various disciplines related to its research programmes. Table 1 provides a summary of staff qualifications. It should be noted that this table does not include the support unit staff, who have distinguished qualifications in their areas of expertise. Furthermore, the technical staff at KISR is augmented through collaborative linkage and cooperation by many outstanding specialists from leading centres of excellence worldwide.

TABLE 1. KISR TECHNICAL MANPOWER

Degree held	Kuwaiti	Non-Kuwaiti	Total
Ph.D.	58	54	112
M.Sc.	110	24	134
B.Sc.	236	..	236

Notes: Two dots (..) indicate that data were not available.

KISR facilities

KISR has a large number of state-of-the-art, specialized laboratories, pilot plants and experimental stations. The Institute has over 40 specialized laboratories associated with the needs of various research programmes, in addition to a central analytical laboratory (CAL). Furthermore, the Institute has many research pilot facilities and plants; the major ones are listed in table 2.

KISR commercializable R and D experience and achievements

Since its establishment, KISR has focused on linking its R and D activities with national economic and human development needs and requirements. Examples of the Institute's commercial achievements and R and D outcomes over the past three decades are presented in table 3. The impact of these activities has led to the development and enhancement of the concerned sectors. For example, the commercial outputs of R and D by KISR in the fields of aquaculture and fisheries are reflected in the increased production of local fish commodities as well as better management and conservation of fish resources. Another similar achievement has also been accomplished in the tissue-culture field, in which R and D outcomes could significantly increase the production of tissue-cultured palm trees to meet local demand in a relatively short time. R and D on salt-tolerant trees and plants is also under way and is expected to achieve similar results. Other successes have also been experienced in other areas of R and D at KISR.

A proposed mechanism to facilitate cooperation

International cooperation is defined as the collaboration of two or more countries in coordinated work in order to achieve certain previously agreed goals and objectives. It is regarded as a basic means for progress and development and for improving the standard of living of the peoples of the world, especially the peoples of developing countries. Through this cooperation, knowledge is transmitted and science and technology are disseminated. To many countries, international cooperation has two sides, give and take: a country offers what it can in response to the requests of other countries and tries, at the same time, to get what it needs. There are many levels of international cooperation, including the international cooperation represented by the United Nations and its specialized agencies.

In the light of complicated international relationships, international cooperation has come to constitute a basic and essential means for development in various fields. This is because the process of development is a reaction between man, with his scientific and technological potential, and his environment, with all its resources and riches. This means that international cooperation relies on three principal elements: man, knowledge and natural resources. The rates and levels of comprehensive development depend on the availability and efficiency of each element. Therefore, all forms of international cooperation have come to concentrate on how to use such cooperation as a means for developing these elements.

TABLE 2. KISR MAIN RESEARCH PILOT PLANTS/FACILITIES AND EXPERIMENTAL STATIONS

Tissue culture and genetic engineering pilot facility	Desert plant development station
Wastewater experiment station	Automated greenhouse
Geotechnical facilities	Range research grazing facility
Semi-commercial poultry research facilities	Coastal engineering pilot plant
Bioassay pilot plant	Ja'aidan garden experimental site
Sheep production research facilities	Brood stock, handling, hatching and grow-out facilities
Catalytic oil cracking pilot plant	Polymer development pilot plant and experimental station
Reverse osmosis pilot plant	Feed storage, cold room and freezers
Oil hydrotreating pilot plant	Eight seismic monitoring stations
Artificial water recharge testing station	Bioassay and biological oceanography laboratories
Oil distillation pilot plant	Research vessels
Subsurface drainage testing stations	Burgan oil lake remediation test site
H-oil pilot plant	Mobile environmental laboratories
Halophyte testing station	Wastewater treatment pilot plant
Petroleum technology laboratories	Mariculture and fisheries, dry and wet laboratories
Waterfront testing site	

TABLE 3. KISR COMMERCIALIZABLE R AND D ACHIEVEMENTS

R and D area	Achievements
Aquaculture	- Aquaculture technologies - Incubators hatchery/grow-out facilities
Embryogenesis culture of date palms	- Tissue culture technologies and incubator facilities
Biomass and biosurfactant	- Production technologies, incubator pilot facilities
Bioremediation of oil-contaminated soil	- Modified bioremediation technologies
Sheep production	- Development of cross-breeding, feeding and proprietary know-how
Fish fingerlings mass production	- Development of technology and hatchery facilities
Ornamental nursery production	- Technology know-how and national greenery plans
Poultry production	- Competitive technologies for broiler and egg production
Polymer development	- 12 commercializable polymer patents
Oil production catalysts	- Improved oil catalysts for proprietary developments
Petroleum additives	- Several improved petroleum additives

TABLE 3 (*continued*)

R and D area	Achievements
District cooling	- Capabilities to utilize district cooling
Laser fluorosensor	- Computerized airborne detection system
Infrared imagery ordnance detection	- Technical expertise for commercial development
Artificial recharge of aquifers	- Pilot-scale capabilities applicable on a large scale
Wastewater treatment and utilization	- Capabilities for large-scale applications
Water desalination by reverse osmosis	- Pilot-plant facilities - Pioneering expertise in the area
Analyses of materials	- State-of-the-art advanced facilities
Information technology	- Wide range of information technology capabilities
Training	- Competent human and physical resources for a wide range of technical and management training

The development of the international economic system has led to the division of the international economy into (a) small number of progressing countries that possess the three main elements of development (human power, scientific and technological knowledge, and natural resources), and (b) a large number of developing countries that lack natural resources and are characterized by weakness of scientific and technological potential. The developing countries can further be divided into (a) poor countries (lacking both natural resources and scientific and technological potential and (b) rich countries (lacking scientific and technological potential).

International cooperation, which aims at developing and strengthening technical, scientific and technological national potential, is thus regarded as the principal means for completing and developing the elements of comprehensive development in these countries.

Since its independence, Kuwait has been active in the technical, scientific and technological fields of international cooperation within the framework and strategies of comprehensive development programmes of different levels—bilateral and collective. With the increase in the pace of development, the strengthening of the State's basic structures, and the growth of the national potential in various fields, and as a result of believing in the importance and necessity of running the International Cooperation Department in such a way as to serve the strategic objective of comprehensive development, Kuwait has become one of the pioneering States in the field of international cooperation at all levels.

Kuwait and cooperation at the Gulf level

Because of the great similarity among the Arab Gulf States in economic, social and cultural characteristics, the Gulf region constitutes an economic and social unity. This unity has started to emerge, at the practical level, among the Gulf States through effective cooperative relations and joint coordination. Kuwait plays a principal role in strengthening cooperation among all Gulf States through such effective cooperative relations and joint coordination for the benefit of the region.

A careful look at various fields of cooperation among the Gulf States shows that all are aimed at enforcing the Gulf States' potential to promote their development. It is hoped that the Gulf States will have, in future, a self-driving power that will coordinate various development projects. In this respect, Kuwait and other Gulf States encourage the exchange of expertise and technical and technological information related to various development sectors. Kuwait also endeavours to coordinate and unify cooperative efforts with progressive countries in order to make use of their scientific and technological experiences.

Kuwait and cooperation at the Arab level

Kuwait regards Arab economic unity as one of the basic strategic goals of its future long- and short-term development plans. In this respect, Kuwait supports, within a framework of Arab cooperation, joint Arab activities in various fields of development through participation in joint projects. Kuwait also supports the League of Arab States and its specialized organizations.

Kuwait participates in numerous joint Arab projects, especially industrial, agricultural and constructive projects, involving Arab specialized companies established by the Organization of Arab Petroleum Exporting Countries (OAPEC). A careful review of most of these projects shows that some of the results are increasing Arab ability to assimilate modern science and technology and to use them for promoting the development processes in various economic and social fields, which will bring great benefits to Kuwait and to the Arab world in general.

As for Arab organizations and their specialized agencies, Kuwait participates in their activities and supports them so that they will be able to undertake their responsibilities and achieve their goals. Kuwait is the host country for some of these organizations: OAPEC, the Arab Planning Institute, and the Arab Fund for Economic and Social Development (AFESD).

Arab organizations and their specialized agencies exert efforts to develop scientific and technological Arab potential through establishing joint projects and organizing specialized seminars and training cycles. They also coordinate and unify Arab positions in the fields of international cooperation, particularly those related to strengthening the Arab countries' potential to assimilate modern technology and to apply scientific results to various fields of development.

At the Conference of Arab Ministers Responsible for the Applications of Science and Technology for Development (CASTARAB), held in Rabat in 1976, Kuwait played a positive part in making recommendations and drafting resolutions generally aimed at developing scientific and technological Arab potential and supporting the efforts to carry out scientific and technical projects on the Arab and regional levels. Kuwait has also worked with other Arab countries on the establishment of an Arab fund for financing scientific research and studies.

Kuwait and international cooperation

Kuwait is endeavouring to enhance its foreign relations. As a member of the international community, Kuwait does not limit its activity to the regional field, but extends it to more comprehensive areas. Kuwait therefore participates effectively and widely in many international organizations and bodies.

UNDP is regarded as one of the most important bodies of the United Nations, and plays a positive part in helping developing countries to develop and strengthen their development plans by offering technical assistance in all different forms.

UNDP assists developing countries in their efforts to speed up the process of economic and social development by offering continuous and systematic assistance to meet the goals of national development plans. Kuwait has played a positive and effective role in strengthening and directing activities of UNDP programmes. UNDP also plays an effective role in helping Kuwait in some of its development projects. An example is the Kuwait national programme, which clearly has benefited from the technical assistance and supervision offered by UNDP to Kuwait in executing projects requiring technical expertise within the framework of national development plans.

To obtain the greatest benefit possible from cooperation in this field, Kuwait has adopted its own local policy in this respect and requests the assistance of experts and specialists to carry out some tasks. The goal is to make use of these experts to train and develop national manpower in all fields in order to reinforce national potential in the technical, scientific and technological fields.

Developing countries, including Kuwait, are calling for a new international economic system that will bridge the scientific and technological gap between progressive countries and developing countries, in order to give the developing countries the chance to make use of progressive countries' expertise and to strengthen their scientific and technological potential. In this respect, Kuwait has participated effectively in numerous international assemblies and conferences.

As a result of the growth of the United Nations system and the increase in the number of international organizations and specialized agencies, more attention has been given to science and technology. Many conferences on scientific and technological cooperation have been held in the past few years, including the 1997 United Nations Conference on Environment and Development, the 1996 Second United Nations Conference on Human Settlements (HABITAT II), the 1994 International Conference on Population and Development, and other conferences covering food security, industrialization, oceans, and water resources.

In addition, the countries of the world have started to urge the United Nations to play a principal and effective role in this respect, and the General Assembly has also urged the United Nations to take on this role through UNCTAD, UNIDO, UNESCO, ILO, FAO, WIPO, WHO and UNDP.

Although the tasks and responsibilities of these organizations are directly related to scientific and technological affairs, other international organizations and specialized agencies can contribute, in one way or another, to the development of international scientific and technological cooperation.

To facilitate potential R and D cooperation within the ESCWA region, the following preliminary measures are recommended:

(a) Establishment of a coordination office for R and D cooperation in the ESCWA region;

(b) Development of expert committees to set/ outline regional and local R and D policy and related activities;

(c) Establishment of the necessary regional and associated local subcommittees to identify areas of common interest to ESCWA members;

(d) Establishment of a regional database/ information network on R and D resources and accomplishments in the ESCWA member countries;

(e) Holding of periodic meetings, as needed, for follow-up and monitoring the progress of the proposed cooperation;

(f) Establishment of the necessary links with regional and international governmental authorities to support the proposed cooperation;

(g) Establishment of the necessary links with regional and international non-governmental organizations to support the proposed cooperation;

(h) Establishment of the necessary marketing committees/offices to promote R and D activities and their potential market investments/applications;

(i) Urging United Nations bodies and agencies to use their influence on Governments in soliciting the moral and financial support for R and D in the region;

(j) Initiation, under the umbrella of ESCWA pilot projects, of action to facilitate the proposed cooperation.

Summary and conclusions

The authors believe that the current R and D cooperation schemes in the ESCWA region should be reassessed to further enhance the various aspects of regional development (economic and human). General guidelines and recommendations were presented in this article. Initiation of work based on these guidelines would greatly enhance the region's development requirements and responsiveness to the challenges of the new international open market environment.

Unless a competitive multi-perspective regional strategy in this regard is formulated, regional development will continue to deteriorate. This deterioration could result in an out of control situation that might drastically disrupt the region's economic stability. The task of developing a strategy necessitates joint efforts at the national, regional and international levels. More involvement is certainly needed to enhance the role of the developing countries in all aspects of R and D development.

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Cooperation between universities and job sectors in fields of R and D in Iraq*

By

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Introduction

The development of technological knowledge, in the view of economists, is both a consequence and a cause of industrial growth. In order to expand and develop its industrial foundation, the industrial sector in developing countries finds itself increasingly dependent on imported technology. This imposes full dependence on the countries that export that technology. In order to reduce the size of this dependence, serious efforts must be made to increase reliance on local scientific and technological capabilities to develop the existing industrial sector and to work out new patterns of local technologies that meet the needs of the country. This task can be carried out by departments of research and development within the industrial sector. However, most such departments are non-existent in the industrial sectors of developing countries. If they do exist, their tasks and capabilities are limited and the basic objective of the production sector is limited to achieving the production plans. In all cases, research and development in the industrial fields should not be regarded as an activity restricted to the industrial sector alone. It is an activity that extends to, and interacts with, many other activities, thus influencing them or being influenced by them: hence the importance of research efforts in universities and institutes and the urgent need for their effective contribution to joint research projects with the industrial sector. The immediate aim is to secure the continuity and development of this sector, with the ultimate aim of reaching an advanced stage of local self-sufficiency capable of coping with developments in world technology. Furthermore, the universities are capable of playing an important role in adjusting their curricula and teaching programmes in such a way as to ensure a technological output (workforce) that satisfies the changing needs of the industrial sector in the light of technological progress.

I. DOMAINS OF RESEARCH COOPERATION BETWEEN UNIVERSITIES AND THE INDUSTRIAL SECTOR

We may classify the domains of cooperation in the field of research and development between the universities and the industrial sector for the purpose of solving the latter's problems as follows:

A. FINDING SOLUTIONS FOR PROBLEMS OF EXISTING TECHNOLOGIES

1. Finding local or more appropriate alternatives to raw materials.

2. Solving scientific and technological problems that face the industrial project and prevent it from achieving full designed capacity.

3. Studying additive materials, supplementary materials, packing and wrapping materials, and working out suitable alternatives.

4. Studying the industrial waste and by-products and assessing the possibility of using them in other fields to increase their economic value.

5. Carrying out research related to environment protection and industrial safety.

6. Studying ways of minimizing waste and improving quality for the purpose of reducing costs.

B. ADAPTING AND DEVELOPING EXISTING TECHNOLOGIES TO SUIT LOCAL CONDITIONS

1. Reassessing production lines for the purpose of adapting them for the use of alternative raw materials or for improving quality; this may necessitate changing the technological paths to produce new materials that meet the market needs.

2. Studying the production operation for the purpose of best utilization of available human and material resources and other types of input.

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3. Improving performance efficiency of various production units and, as a result, improving the efficiency of the project.

4. Improving product specifications and introducing concepts of quality assurance.

5. Continuous development of the control systems of the production operations in order to arrive at a product with consistent specifications.

C. Introducing up-to-date know-how and technologies

1. Investigating the use of new technologies and understanding the mechanisms of their operations.

2. Establishing up-to-date technologies and suggesting their gradual introduction in the national industry.

3. Facilitating the know-how of complex technology.

D. Qualifying and developing industrial staff

1. Contributing to programmes for developing and qualifying the industrial personnel through running continuous education and training courses and holding scientific conferences and specialized symposia.

2. Inviting senior scientific staff members of the industrial sector to take part in university teaching and research projects.

3. Raising the standards of the engineers and technicians by accepting them in higher studies programmes, and by encouraging them to select research projects relevant to the problems that their industries encounter.

4. Participating in developing the infrastructures of applied research in the industrial sector, especially the research areas that concern information, scientific documentation and patents.

II. BEGINNINGS OF THE COOPERATION IN RESEARCH AND DEVELOPMENT BETWEEN THE UNIVERSITIES AND THE INDUSTRIAL SECTOR IN IRAQ

The beginning of the 1970s witnessed the start of the research cooperation between the universities and the industrial sector in Iraq. Specialized action committees were formed of university teaching staff and senior scientific staff in the industry. Each committee was responsible for a certain factory. The members visited the factory regularly and conducted studies and research work in order to contribute to solving some of the factory's problems, and thus help its development. However, despite the variety of studies and research work carried out and the consultation offered directly to the factories, the committees, in general, did not achieve significant success leading to noticeable development in the industrial sector.

During the 1980s, each university prepared formulas for cooperation with user sectors based on their needs. This was effected through direct coordination with university consultative bureaux or research centres. The 1980s witnessed increasing mutual understanding and closer affinity between the two parties. On the whole, there were no clear and consistent formulas for cooperation, nor were there clearly stated objectives and policies. The cooperation concentrated on finding solutions for existing problems to relieve certain production constrictions. Occasionally, these efforts led to registering patents and scientific studies, some of which were carried over to the industrial design stage. However, these cases were characterized by a lack of continuity and by heavy reliance on personal efforts, and they concentrated on the engineering, extraction, design, and construction industries and some chemical industries.

III. ASSESSMENT OF THE EXPERIMENT

A number of obstacles impeded the expansion of research and development between the universities and the industrial sector. Both parties were responsible for these problems. We state here as objectively as possible the most prominent of these problems.

A. The industrial sector

1. The industrial sector's conviction that the university was incapable of solving industrial problems.

2. The industrial sector's unwillingness to disclose the type of industrial problems that it suffered from and that could be the subject of a research project.

3. The industrial sector's inability to define the type of problem from which it suffers.

4. Insufficient funds to support projects of research and development.

5. Non-existence of research and development departments in many industrial establishments.

6. The fact that many of the industrial projects were turnkey projects.

B. THE ACADEMIC SIDE

1. Many academic teaching staff members lacked the industrial expertise to enable them to understand industrial problems well enough to propose solutions.

2. The treatments offered by academic teaching staff members were characterized by the use of traditional methods that explored the depth of the subject in order to get at the details, thus exhausting a lot of effort and consuming a lot of time to arrive at a solution to the problem under study. This is why the industrial sector resorts to special expertise firms in industrial countries to arrange solutions at very high financial costs.

3. Because of their academic commitments, the time available to the teaching staff members was too limited to allow them to participate in industrial research development.

4. There is a lack of rewarding financial incentives for university staff members to do research and development.

5. The response of universities to the demands of the industrial sector has been slow, owing to red-tape routine.

To sum up, one may say that the absence of a specific relationship linking the universities to the industrial sector, and the non-existence of a coherent mechanism that was acceptable to all parties concerned to organize the joint work, led to the failure of development of cooperation.

IV. REORGANIZATION

The presence of a university is always linked to intellect, scholarship and civilization, which control the patterns of change in the society and its qualitative and historical moves from one stage into a better one. The role of the universities in Iraq has been restricted mainly to preparing graduates and conducting academic research. The universities' role is non-existent in the interaction with social institutions to cope with the fast circulation of knowledge and to secure the need for a well-qualified workforce. Their role in the service of the society has remained limited, unlike the universities of developed countries whose activities have penetrated fields of work, thereby establishing for themselves a sufficient, clear role in the solution of production problems. However, the activities of the Iraqi universities have expanded in a balanced consistency proportionate with the rise in the standard of industry and technology that Iraq has witnessed, particularly during the past 15 years. This state of affairs has necessitated the activation of scientific and research centres in the universities and the organization of the relationship between the universities and clients. The purpose is to encourage the universities to assume their natural role in research and development and enable them to respond to the demands of the advancements in civilization and the achievements of development in the society.

The Symposium on Higher Education Development in Iraq, held in the summer of 1992, was the real starting point for the organization of the relationships and for building bridges of cooperation between the universities and different job centres and the transfer of solutions from university laboratories and research centres to job centres. In this way, the universities actively participate in research and development for the benefit of various job sectors in Iraq. One of the most prominent results of the Symposium was the initiation of a quiet and purposeful dialogue based on the faith and conviction that there are scientific capabilities of a high standard that need to be well utilized. The aim is to arrive at outcomes having a clear effect on the current demands of life in Iraq and on the enrichment of scholarship and scientific research so that the universities will be well-established centres for intellect and expertise that interact with both the realities and applications of job sectors at a time when unfair sanctions are imposed on the people of Iraq.

A. COOPERATION BASES

A university teaching staff member is usually qualified enough to conduct applied research. One qualification is the advanced academic degree that the staff member has in his/her field of specialization; another is his/her awareness of what is new in his/her field, and knowledge of the contributions of other scholars who share the same interests, knowledge that the staff member develops through follow-up of scholarly research publications, regular attendance at regional and international conferences and visits to other universities. A further qualification is adequate training in methods and techniques of research and competence in obtaining needed information from references. These qualifications enable the university teaching staff member to contribute to research and development for the benefit of general social institutions.

To enable the university teaching staff member to carry out an applied piece of research that is both useful and important to job fields, the staff member needs to have the following:

(a) A practical problem with a specific and clearly stated aim;

(b) Sufficient funds to support the research/ development programme;

(c) Provision of necessary research requirements needed to carry out the job;

(d) The availability of flexible administrative and financial regulations and standards that facilitate the appropriate use of the funds;

(e) The availability of a database;

(f) A flexible arrangement for teaching commitments that facilitates the work of the staff member in research and development;

(g) Financial, academic and moral reward for his/her work.

These requirements can be incorporated in a mechanism for work organization and coordination between the universities and various client sectors and for specifying the obligations of each.

B. Procedures

After the above-mentioned Symposium on Higher Education Development in 1992, the Office of Research and Development was established in the Ministry of Higher Education and Scientific Research. The Office has the responsibility of coordination and cooperation with job sectors. The first step that the Office took was to call all job sectors to participate in a constructive dialogue on their expertise and previous participation in the fields of cooperation. The Office made solid suggestions, observations and recommendations characterized by the highest degree of objectivity and concern for the success of the cooperation plans. The dialogue continued to bring to fruition the proposed methods, arrangements and mechanisms of cooperation among all parties concerned in the fields of research and development. It was obvious from the start that one of the basic requirements for pooling resources and capabilities and utilizing them was to agree on a clear and simple work mechanism. This mechanism specifies methods, contributions and commitments of various sectors in troubleshooting and solving technological and production problems, developing and improving existing technologies and introducing up-to-date expertise and technologies to the society. The aim is to arrive at a state of scientific technological progress and advancement which would build up a strong self-sufficient society that relies on its own capabilities and that is not shaken by the sanctions imposed on it.

The various sectors participating in the dialogue were able, through detailed discussions with the universities, to formulate a document of cooperation that organizes the cooperative relationship between the universities and job sectors, especially in the fields of research and development. This document was approved by all parties concerned and was designated the "Document of Cooperation Mechanism". The document was put into effect at the end of 1992.

C. Document of Cooperation Mechanism

The Document of Cooperation Mechanism classifies cooperation domains in the fields of technology, engineering, agriculture, economics and administration into three types:

1. *Cooperation in urgent matters*

(a) *Cooperation domains*

These cover urgent matters that require immediate contact to conclude an agreement. The implementation should be completed in a short period not exceeding six months. The domains cover the following:

(i) Preparing theoretical studies, specifying relevant measures, economic evaluation, executing inspection, carrying out analyses and monitoring quality;

(ii) Executing pilot experiments;

(iii) Approving designs;

(iv) Providing consultation;

(v) Searching for suitable alternatives to facilities and raw and supplementary materials.

(b) *Execution mechanism*

(i) Direct contact and immediate conclusion of agreement between specialists in the organization unit of the industrial sector and the relevant university department;

(ii) Fast response by the two contracting parties to the job demands and their compliance with the agreed-upon programme.

(iii) Arranging a form of agreement or contract concerning job organization, with the arrangement stating the financial, moral and academic rewards for both contracting parties, a full job description and specifications as to the execution period.

(iv) Conferring upon the university departments and the organizing units in the sector the authority:

a. To approve the agreement formula between the university department and the job sector;

b. To approve the presence and work of members of the two contracting parties at both work sites;

c. To make available the required facilities, materials, equipment, work sites, or to include them in the contract;

d. To make available facilities of accommodation and transport to and from work sites for the members of both the contracting parties, or to include them in the contract;

e. To adjust the tasks of the members of each of the contracting parties to suit the scope of the required job.

2. *Cooperation in matters for the medium term*

(a) *Cooperation domains*

These include defined or definable matters that can be executed within a relatively longer period of time, not exceeding two years. The domains covered include:

(i) Preparing studies and conducting research concerning the facilities, raw and supplementary materials and job requirements;

(ii) Conducting field studies for industrial, agricultural, oil and service projects and finding solutions to secure:

a. That production reaches designed capacity;

b. Quality assurance or quality improvement;

c. Development of fields of production by using alternative or new raw materials;

d. Conversion of technological paths of production in order to produce or prepare new materials;

e. Optimal utilization of material and human resources available;

f. Economizing in energy and other inputs;

g. Cost reduction through running specialized administrative programmes and systems.

(iii) Preparing of basic and detailed designs to develop existing projects or construct new ones;

(iv) Conducting studies and research on industrial, agricultural and service waste;

(v) Conducting studies and research concerning protection and improvement of the environment;

(vi) Conducting studies and research concerning professional and industrial safety;

(vii) Conducting studies and research on diseases and epidemics that affect agricultural products and livestock;

(viii) Developing and manufacturing work tools, measurement and testing equipment, insecticides, drugs and veterinary vaccines.

(b) *Execution*

(i) Direct contact between the organizing unit of the job sector and the relevant department at the university;

(ii) The relevant department and college take upon themselves the task of organizing the job and obtaining the necessary approvals through the chairman of the branch committee of research and development in that university;

(iii) The relevant college and the organizing unit undertake the task of approving the job plan within two weeks;

(iv) Conferring upon the department, college and the organizing unit the authority stated above (see item 1 [b]);

(v) Arranging a form of agreement or contract between the two parties that organizes the work, states the financial, moral and scientific rewards of the two contracting parties, and includes a description of the required job and the period of execution;

(vi) Compliance of the two parties with the contract between them.

3. *Cooperation in matters of a continuous nature*

(a) *Cooperation domains*

(i) Carrying out joint research in the fields of existing, planned or prospective technologies;

(ii) Carrying out joint research in specific scientific and technological fields;

(iii) Approving research proposals for postgraduate degrees (master's and doctoral) based on the sector's programmes;

(iv) Initiating or promoting undergraduate or postgraduate studies or introducing or modifying courses that fall within fields of specialization that serve the sector's programmes;

(v) Joint implementation of projects through their different stages: basic and detailed studies, and laboratory work and pilot experimentation;

(vi) Development of scientific knowledge, creating change in it and adapting it in a way that is responsive to the nature of the local conditions and needs of the society;

(vii) Conducting joint studies and research concerning existing, planned or prospective irrigation projects that aim at improving the efficiency of water use and preserving the soil.

(b) *Execution mechanism*

(i) Setting up a committee or a control body of all parties concerned to supervise the job and follow up the stages of its execution;

(ii) Holding one or more meetings attended by specialists from the universities and job sectors to discuss the scope of cooperation and define the nature and aims of the job;

(iii) Setting up specialized committees representing the concerned parties to prepare studies on the detailed requirements of the job with the aim of preparing a programmed plan and specifying the executing teams and the role of each;

(iv) Agreements or contracts are concluded among the parties concerned according to the arrangements noted above in this section.

Later, the cooperation mechanisms were expanded to cover the mechanical field. The cooperation mechanisms set up for the social and medical fields and humanities are similar in their general framework to that reviewed above.

Late in 1992, a law was passed permitting the university teaching staff members to offer consultation and research services in return for agreed-upon fees; 80 per cent of the returns from the applied research is awarded to the university action teams, and the remaining 20 per cent is spent on developing the concerned college or university. Thus, the contracts signed in accordance with the cooperation mechanism have a legal framework governing the use of financial returns.

V. EXECUTION CHANNELS

Subsequent to the large-scale cooperation that took place between the universities and various job centres, numerous channels of contact were established and expanded, characterized by high flexibility in selecting the appropriate type of contact for each individual case.

We may here call attention to the most important means of contact that have actually been used during the past five years following the approval of the cooperation with job sectors.

A. The cooperation mechanism

In every college a committee is established and designated as the Cooperation Mechanism Committee, whose responsibility is to conclude contracts with client sectors to solve a research problem through a specialized action team.

The commitments of each party are determined at the outset, and these include provision of research tools and equipment, the required funds, names of the action team, duration of the research, and financial and moral commitments for the members of the action team.

The action team may include a member from the client's party to coordinate and participate in the research. The relevant college is usually allocated 20 per cent of the profits that these contracts make.

B. Consultative Bureaux

Current laws permit the establishment of a consultative bureau in each college or institute to offer services to users within its field of specialization. There are consultative bureaux in most colleges. They have financial and juristic independence from the college. Teaching staff members work in these bureaux on a part-time basis. The consultative bureaux provide the expertise of specialized staff members. Since the first law in this field was passed in 1979, the consultative bureaux have been participating effectively in research and development to solve technological problems, to provide designs required by various sectors and to construct and operate pilot plants.

Contracts are made between the director of the consultative bureau and the users for conducting the required research, and these contracts specify the commitments of each party.

The consultative bureau then assigns the task to an action team. The execution of the job according to the required specifications is the responsibility of the consultative bureau, which, in order to ensure the precise execution of the contract, may change members of the action team if required. That is how the basic relationship is set up between the consultative bureau and the clients.

C. Postgraduate Theses

The theses of postgraduate students contribute to research and development for job sectors by taking on their practical problems. The client sector may assign one of its employees, who is admitted as a postgraduate student, the task of studying a certain problem through coordination and prior arrangement with the relevant university department. The teaching staff who are engaged in research for the benefit of the job sectors may assign the study of the academic problems to the postgraduate students that they supervise. In both cases, the client sector will allocate funds to complete these studies. In other cases, some sectors announce a list of subjects that they believe is worth postgraduates' attention. Here no financial support is offered. The supervisors and their students then select what interests them as postgraduate projects. Financial support is provided by the university. The sectors that have made the proposals may offer such facilities as use of equipment, relevant software, or data available on the topics.

D. Personal Agreements

The university teaching staff may offer their services in the field of research and development to clients through direct arrangement. Such arrangements are usually made subject to the approval of the college and university, but they are not responsible, except in a moral sense, for the results of the arrangements. Work is usually carried out under the supervision of the clients, not the university. Such a type of arrangement may take one or more of the following forms:

1. *Direct contact to conduct a specific study*

The clients may directly conclude a contract with a university teaching staff member to conduct a study or investigation under the sector's supervision. The investigation may be conducted in the university or the client's institution and according to a prior arrangement. The researcher will be directly responsible to the clients.

2. *Contracting as a consultant*

The clients may conclude an agreement with the university teaching staff member to work as a consultant in their institution with the responsibility of offering technical, administrative or economic advice in return for monthly or annual financial allocations agreed upon by the two parties. The university teaching staff member is in this case directly responsible to the clients.

3. *Contracting as an expert*

The clients may conclude an agreement with a university teaching staff member whereby he or she is employed as an expert in their institutions with the responsibility of assessing studies and reports that are referred to him/her and stating a competent opinion based on his/her expertise. This is arranged in return for a monthly or annual financial allocation or reward and in accordance with the contract. The work relationship is direct between the two parties.

4. *Short-duration secondments in the job sector*

University teaching staff members may be seconded to different job sectors during the summer holidays. This is arranged through prior coordination between the university and the clients. The seconded staff member will participate in investigating the problems that face the institution for which he/she works, and in finding appropriate solutions.

In this way, the staff member is expected to obtain further experience based on activities in the work site to which he/she is seconded. He/she is also expected to come up with research project proposals based on the state of affairs at the institution where he/she works. These proposals may then be adopted by the university or by postgraduate students for research purposes.

The clients in this case pay the salary and other allowances to the seconded member during the period of secondment. After the secondment, the teaching staff member may continue to work for his/her clients as a consultant or expert.

VI. RESULTS OF THE ORGANIZATION

The results of the openness policy between the university and job sectors have been overwhelming during the past five years. It has removed all psychological and administrative barriers between the universities and the different job sectors and created mutual confidence between the two parties. Since the approval of the new formulas of cooperation, thousands of contracts of research and development between the universities and different job sectors, especially the productive ones, which are more capable than other sectors of funding the research they need for development. These jobs include several outstanding studies and investigations that have resulted in finding local alternatives to some imported raw and additive materials, and in the development of production lines and existing technologies, providing designs and offering scientific, technical, administrative and economic consultations. The number of applied research studies that the universities have completed totalled 8 per cent of all the research projects carried out by university staff members since 1992. The research commitment that a university teaching staff member has to undertake is at least one research project per academic year. The percentage referred to above, which represents research for developing client sectors according to contracts, is considered one of the best percentages of applied research work in universities by standards in many parts of the world. The percentage reflects the extent of cooperation between the two parties and the confidence that the production sectors have gained in the potentialities of the academic staff. It also reflects the staff members' orientation towards research and development and their understanding of the job sector's problems. When in need, production factories now resort to university teaching staff members even if the universities are geographically remote from the work sites and conclude contracts for promoting the quality of their products by solving specific problems through applied research. It should be noted that the private sector is usually unwilling to invest in research and studies that do not achieve fast and obvious financial returns. However, because of the increase in confidence between this sector and the research institutions, and because of its awareness of the type and quality of the university staff members' services to the State and mixed production sectors and the positive outcomes obtained by these sectors, the private sector has started during the past few years to request the university's assistance in research and development through the Cooperation plans. The universities have conducted a number of studies and investigations for the benefit of the private sector, as well as engineering designs, feasibility studies and studies on costing. Since 1992, research completed for the benefit of the private sector has accounted for 15 per cent of completed research and development for different types of production sectors. This is considered a reflection of the vast development in the relationship between the private sector and the universities compared with the modest size of cooperation that existed earlier.

VII. FUTURE PROSPECTS

The Iraqi universities achieved great success by moving confidently, steadily and with increasing momentum into research and development. They opened their doors wide to cooperation, while ensuring that the modalities for that cooperation and coordination were agreed and well understood by all the concerned parties. The universities have now started to plan for another, more advanced stage of their relationship with the job sectors: the initiation of master projects. There are already promising beginnings for these new orientations but it is still too early to judge how successful they will be until the more advanced stages have been completed.

Selected biotechnologies for crop improvement in ESCWA member countries*

By

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Abstract

ICARDA biotechnology aims to support the ICARDA crop-improvement objective of providing the National Agricultural Research Systems (NARS) with well-targeted biotic and abiotic stress tolerant cultivars and genetic stocks. For this, different biotechniques are evaluated, adapted and finally applied in ICARDA research programmes. Emphasis is given to the identification and exploitation of genetic resources for sources of improved stress resistance, particularly improved water use efficiency. Non-radioactive DNA (deoxyribonucleic acid) technology is utilized to establish marker-assisted selection systems. The adoption of DNA-marker technology and the formation of core collections will also improve the efficiency of germplasm collection management and use. *In vitro* techniques are being used to overcome species barriers to introgress agronomic traits of wild species into cultigens. Doubled-haploid breeding is used when rapid solutions are required. When variability for key traits is low, genetic transformations are used to incorporate new genes into plant materials: this work is carried out in collaboration with advanced institutes.

Introduction

ICARDA holds the world mandate for crop improvement of barley, lentil and faba bean, and a regional mandate in the West Asia and North Africa (WANA) region together with the International Centre for Research in the Semi-Arid Tropics (ICRISAT) for chickpea, and the International Centre for Wheat and Maize Improvement (CIMMYT) for durum and bread wheat. Biotic and abiotic stresses are major limitations on yields of cereal and legume crops. The objective of the crop-improvement programme is to increase yield and yield stability under variable arid and semi-arid conditions. Under these conditions, crop yields are generally low and vary greatly from year to year.

The conventional empirical selection strategy applied by plant breeders involves repeated cycles of selection for agronomic performance and stress resistance combined with multilocation testing. Breeders are seeking to increase both the heritability of desired traits and the frequency of desirable individuals within a breeding population. As breeders strive to improve germ plasm and extend the range of adaptation, the number of traits that must be incorporated into new cultivars increases. The simultaneous or sequential screening for multiple biotic or abiotic stresses may be impractical or impossible. The use of DNA-marker technology can help to identify genetic linkages to qualitative and to quantitative traits. It is envisaged that, for the key biotic (and abiotic) stresses in ICARDA-mandated crops, molecular markers closely linked to the traits of interest will be developed. These markers will be converted in easy-to-use PCR (polymerase chain reaction) markers to allow marker-assisted breeding for the key stresses.

In cases where insufficient variability exists within the cultivated crops, interspecific hybridization supported by ovule- and embryo- rescue techniques, is used to introgress new sources of resistance. Doubled-haploid techniques are used in the cereal crops where fast advancement of populations is required. If variability for a specific trait cannot be found in either the cultivated crop or in wild relatives, methods of transformation of alien genes are used to provide resistant germ plasm.

Selected biotechniques used at ICARDA

I. Tissue-culture techniques

1. Doubled-haploid breeding.

   (a) In wheat: the anther-microspore culture system;
   (b) In barley: the bulbosum system.

2. Use of somaclonal variation in Lathyrus.

3. Use of ovule- and embryo-rescue techniques for interspecific hybridization.

   (a) In chickpea;
   (b) In durum wheat.

* Paper presented at the Expert Group Meeting on the Assessment and Promotion of R and D in the ESCWA Member Countries, during the working group session on R and D in water resources and water treatment and selected agricultural biotechnologies.

II. Molecular marker techniques

1. DNA marker for fingerprinting diseases: *Ascochyta rabiei.*

2. DNA marker for biodiversity analysis.

3. Use of molecular markers for gene-tagging in crops.

4. Application of markers for marker-assisted selection.

II.1.(a) *Doubled-haploid breeding in wheat*

The value of doubled-haploid (DH) line production for breeders is the reduced time required to obtain homozygous populations. Regenerated haploid plants of hybrids after colchicine doubling comprise a completely homozygous population. Furthermore, with the introduction of DNA-marker technology in plant breeding for gene-tagging and genome-mapping, DH lines represent the ideal plant material for the application of this technology.

DH breeding for the joint CIMMYT/ICARDA Spring Bread Wheat Programme is used specifically to introgress Hessian fly resistance for North Africa and yellow rust resistance into adapted germ plasm (ICARDA, 1996). Since 1989, the Spring Bread Wheat Programme has used doubled-haploids as the quickest method for incorporating important traits into the germ plasm. Several doubled-haploids are in the last stages prior to release.

Anther-microspore-culture system for doubled-haploid breeding in wheat

The plant material for anther culture is planted in growth chambers under optimal conditions. Spikes are collected when microspores are in the early- or mid-uniculate stage. Spikes are cold treated at 4° C in darkness for four days to induce androgenesis. For anther culture, anthers are cultured in petri dishes and are incubated at 28° C in the dark. After about four weeks, developing calli are collected and transferred to regeneration media. Regular transfer of calli to fresh regeneration media maintains the possibility of green-shoot induction up to three months after first incubation. Plantlets are grown on a plantlet-regeneration medium until four to five tillers have developed. Tillers are cloned *in vitro* to multiply the initial shoot. Subsequently, plantlets are transferred to peat moss and maintained in a growth chamber. When plantlets tiller again, three to five tillers are removed from the pots and treated with colchicine.

The induction and regeneration media used for the anther culture system have been extensively tested elsewhere (Picard and others, 1990; Lashermes and others, 1991; Trottier and others, 1993) and represent some of the best media used for anther culture in wide range of genotypes of bread wheat. Changes in the media composition might increase the frequency of green plant production for some genotypes; however, these media should provide a good standard for a wide range of genotypes. The most difficult factors to control for anther culture in bread wheat, especially in the dry areas, is the temperature for growing the donor plants. The decrease in green-plant production with increasing temperature for the donor plants reduces the possibility of using field-grown plants for this purpose. Spring temperatures in the dry areas are characterized by a sharp rise in March and April. It would, therefore, be impossible to collect spikes at the optimum temperature required for anther culture. Plastic-house-grown plants can be used for the anther-culture system; however, the time for culturing the donor plants would be limited to the winter period if additional artificial light is available.

Frequencies of 10 per cent or more green-plant production are sufficient to generate populations of DH lines from a single cross, if sufficient donor plants are available. However, even a few DH lines from a single cross should enable the screening and the recovering of yellow rust resistant lines within the population, as the resistance is usually inherited as a single gene. Rather than trying to generate many DH lines from a single cross, our goal is to develop DH lines from as many crosses as possible, involving many different sources of yellow rust resistance.

II.1.(b) *Doubled-haploid breeding in barley: the bulbosum system*

DH breeding has been used more extensively in barley than in wheat. Two approaches are common: interspecific crosses with *Hordeum bulbosum* L. and the anther-microspore-culture system (Ziauddin and others, 1990). Crosses between *H. bulbosum* ($2n = 2x = 14$) as the male and *H. vulgare* (cultivated barley) as the female parent lead to preferential elimination of *H. bulbosum* chromosomes in the first eight days after fertilization (Subrahmanyan and Kasha, 1973), thus leaving haploid *H. vulgare* plants. This method is very efficient for haploid barley production (Chen and Hayes, 1989; Pickering and Devaux, 1992). The major limitations hampering wider application of this method are the genotypic and environmental influence on the success rate and the labour required. Similarly in bread wheat, crosses with tetraploid *H. bulbosum* (Inagaki and Tahir, 1990, 1992) and, more recently, maize (*Zea mays* L.) and its relatives are being successfully used to induce haploidy (Laurie and Bennett, 1988; Laurie, 1989), using the same principle of chromosome elimination.

II. 2. *Use of somaclonal variation in Lathyrus*

Consumption of seeds of *Lathyrus sativus* L. is restricted as they contain high concentrations of the neurotoxin α-ODAP (β-N-oxalyl-L-,α-β-diaminopropionic acid), which causes paralysis. A tissue-culture protocol has been developed to obtain plants with a low β-ODAP concentration. Different explants are cultured on a medium where they are dedifferentiated into calli. From these calli, plants are regenerated. Owing to somaclonal variation, a number of these plants will have a considerably lower concentration of α-ODAP than the original seed/variety.

This technique was tried at ICARDA with four local varieties (ICARDA, 1996). Seed colour of the seedlings relates to the amount of toxin in the seed. From 422 explants cultured, 85 per cent were dedifferentiated into calli. Of these calli, 43 per cent regenerated roots, shoots or both on the first media on which they were cultured. Some of the calli have been transferred to a regeneration medium. After two months of culturing, nine explants developed with roots and shoots. Differences in calli formation between the varieties are few. To enhance the somaclonal variation, it is important to have a good callogenic phase before the regeneration is induced. The medium B5L gives many calli which show just rooting; an adjustment in the hormones is being tried to also induce shoot development. The calli with roots or shoots are transferred to regeneration media to induce the development of roots or shoots.

II. 3. *Use of ovule- and embryo-rescue techniques for interspecific crosses in chickpea*

Wild annual *Cicer* species carry useful genes for biotic- and abiotic-stress resistance. In order to use these genes, interspecific hybridization is necessary. Field crosses have so far only resulted in crosses of *C. arietinum* (cultigen) with *C. echinospermum* and *C. reticulatum*. To obtain hybrids of *C. arietinum* with *C. bijugum* and *C. pinnatifidum*, different cross combinations were tried. Six cultivars and three accessions from each wild species were chosen (ICARDA, 1996). The wild species were used as the pollen donors. To enhance pollen-tube growth and ovule development, hormone solutions were applied. Some 1,764 crosses were made, of which 47 per cent were successful (developing ovule). Differences between the accessions were considerable: between 32 per cent and 79 per cent for successful crosses. The number and quality of the ovules also differed between and within the different wild species. Flowers and seeds of *C. bijugum* are larger than those of the other species, which makes the crosses with this species easier. In addition, the ovules that are rescued from crosses with this species are often larger. For ovule-rescue and possible embryo rescue, ovules are needed that have developed normally. They should be dark green without being translucent and seeds should exceed 3 millimetres (mm) in diameter. In general, GA3 seems the best hormone to achieve this. Ovules were cultured on different induction and regeneration media. It was possible to regenerate calli from good-quality ovules, which in some cases develop roots or shoots. A possible hybrid (with roots and shoots) was obtained but did not develop any further. Some regeneration media have been identified that allow the development of an embryo big enough to allow embryo rescue. So far, six embryos have been rescued that developed into plantlets. It remains to see these plantlets through to mature fertile plants.

III. The use of molecular markers for crop improvement

The use of molecular markers for crop improvement was initiated when DNA-fingerprinting techniques were adopted. Nowadays, a number of techniques are used for fingerprinting genetic resources in plants. Numerous molecular-marker systems have also been used for genome-mapping and gene-tagging. Markers have already been identified to be linked with traits of agronomic importance. Besides the efforts of mapping and identifying host-plant resistance, considerable efforts are being made to characterize the pathogen populations. Once host-plant resistances have been mapped and pathogen population characterized, shifts in the pathogen population will allow the deployment of corresponding resistance genes. The technology available for using these markers in marker-assisted selection (MAS) has also greatly improved. The ability to use MAS to pyramid genes will make this technology an essential tool for breeders.

III.1. *DNA markers for fingerprinting diseases: Ascochyta rabiei in the Syrian Arab Republic*

Ascochyta rabiei (Pass.) Labr. is the most severe fungal disease limiting chickpea production, especially in the winter-grown chickpea areas of the Mediterranean region. Conventionally, the population structure of the pathogen is determined by pathogenicity surveys (pathogenic variability) based on the reaction in a set of differential cultivars. Such a study in the Syrian Arab Republic revealed the occurrence of three pathotypes for *A. rabiei*. In addition, a set of microsatellite and RAPD markers were also used (Udupa and Weigand, 1997), which led to the identification of suitable RAPD (randomly amplified polymorphic DNA) markers, allowing a more precise determination of the pathotypes. All the surveys (1991-1995) revealed the predominance of a single genotype (genotype-H) in all the chickpea-growing regions, which was not detected during the earlier survey of 1982 (Reddy and Kabbabeh, 1985). The genotype is increasing in frequency in all the chickpea-growing regions of the Syrian Arab Republic (33 per cent in 1991 to over 80 per cent in 1995). Genotype-H is highly aggressive (pathotype III) and can completely kill the most-resistant cultivar (ILC 3279) released for cultivation in the Syrian Arab Republic.

A pathogenicity survey using DNA markers clearly demonstrated that there is a need to develop chickpea cultivars with stronger levels of resistance to genotype-H of the pathogen. New sources of resistance to genotype-H in chickpea have been identified. It was also established that the level of resistance to genotype-H was improved through conventional pyramiding of resistance genes to *Ascochyta* blight. Since the pathogen seems to migrate through infected seeds, use of disease-free seeds for planting and seed-treatment with suitable fungicides can help in better management of the disease.

III.2.*DNA markers for biodiversity analysis*

RAPD markers were used to assess genetic diversity and evaluate barley accessions to develop a core collection (ICARDA, 1996). A core collection consists of a limited set of accessions derived from an existing germ plasm collection, chosen to represent the genetic spectrum in the whole collection. The core should include as much of its genetic diversity as possible and avoid duplicates. Three hundred and fifteen barley accessions covering the whole WANA region were used for this analysis. Polymorphisms were observed as the presence versus the absence of amplified fragments of the same size. It may be concluded that the RAPD assay is useful for accessing the genetic diversity. The level of genetic diversity in the tested core collection is high. With only three primers, we were able to distinguish between the majority of accessions and to regroup 315 accessions into 98 groups of patterns.

III.3.*Use of molecular markers for gene-tagging in ICARDA-mandated crops*

The use of restriction fragment length polymorphisms (RFLPs) to construct genetic linkage maps was proposed in 1980. RFLP linkage maps have now been made for barley (Graner and others, 1991), bread wheat (Devos and Gale, 1993) and lentils (Eujayl and others, 1996), and the development for chickpea and durum wheat is under way. It has been proposed that linkage maps can be used to increase selection efficiency for qualitative traits and to monitor introgression of alien chromatin into cultivated species. However, more important is the possibility of using linkage maps to analyse quantitative trait loci (QTL) (Lander and Botstein, 1989).

In general, the degree of genetic polymorphism in the ICARDA-mandated crops is limited. Therefore, the application of the marker technology within a breeding programme to assess genetic polymorphism of elite material has so far achieved little practical application. Microsatellite-based markers (Saghai Maroof and others, 1994; Powell and others, 1997) are the most promising technology to be taken up for marker analysis. Microsatellites, also known as simple sequence repeats (SSRs), are ideal DNA markers for population studies and genetic-mapping because of their abundance, high level of polymorphism, wide dispersion in diverse genomes, ease of assay by polymerase chain reaction (PCR), and ease of dissemination among laboratories. Besides the microsatellite markers, amplified fragment length polymorphisms (AFLPs) are a new technology for genetic-fingerprinting and genetic-mapping (Zabeau and Vos, 1993; Vos and others, 1995). The advantage of the AFLP technology is that a relatively large number of informative markers can be generated by the choice of restriction enzyme/primer combination even though the majority of the markers are dominant. Currently, the approach for mapping plant genomes is to map microsatellite markers as anchor probes to identify the linkage group and to fill the gaps with AFLP markers.

Application of molecular-marker systems in barley for QTL analysis of agronomically important characteristics for dryland conditions

Genetic improvement of barley in stressful environments within the WANA region is rather slow owing to the frequency, timing, duration and severity of a number of climatic stresses (Ceccarelli and others, 1991). In addition, powdery mildew (caused by Erysiphe graminis DC. Ex Mérat f.sp. hordei Em. Marchal) and scald (caused by Rynchosporium secalis (Oud.)J.J. Davies) are important foliar diseases in this region. The use of DNA markers combined with multilocation testing over several years might help to identify genetic linkages to qualitative but, more important, to complex inherited quantitative traits important for dryland agriculture. A collaborative research project between ICARDA and the Technische Universitaet München-Weihenstephan is aimed at tagging genes of agronomic importance with molecular markers, and at allowing marker-assisted selection for traits that are difficult to select. A recombinant inbred line population showing variation for traits used for selection in stressful dryland conditions of the Syrian

Arab Republic is being mapped with molecular markers to allow the analysis of qualitative and quantitative trait loci (ICARDA, 1996).

Mapping of the cross Tadmor x WI2291

An integrated genetic map of barley crosses Tadmor *WI2291 and Igri *Franka consisting of 160 marker loci has been constructed using the computer package JoinMap (Version 1.4). While the segregation data set of Igri * Franka was downloaded from the publicly available GrainGenes database, mapping of Tadmor * WI2291 was performed at the Technical University of Munich and ICARDA. Here, segregation data of 48 RFLP and 31 RAPD markers were obtained for the 260 individuals of the cross. Common markers between populations are a prerequisite to and backbone of an integrated map. To find out if markers with the same core name are targeting the same locus, a pre-integrated map was calculated. Markers mapping in a 5-centimetre (cm) distance were considered to represent only one locus, and their names were adjusted accordingly.

TABLE 1. COMPARISON OF DNA MARKER SYSTEMS FOR ANALYSIS OF CROP GENOMES

Marker	No. of polymorphic informative data points	Map resolution (No. of markers placed in a genome)	Marker type
RFLP	1-2	1000	Co-dominant
RAPD	4-6	10000	Dominant
SSR	3-10	10000	Co-dominant
AFLP	10-50	>100,000	Dominant

Having standardized the different marker symbols, 26 markers were found to be common to the two populations (table 2). These markers were evenly distributed over and in the linkage groups, hence allowing unambiguous integration of the two data sets. Marker orders on the integrated map were identical to the orders on the two component maps. Except for chromosomes 4H and 7H, all other chromosomes were well populated with molecular markers, comprising in total 58 intervals in which a QTL analysis in the cross Tadmor * WI2291 is feasible.

*Analysis of agronomical and physiological traits in Tadmor*WI2291*

Traits were evaluated during seed increase in double rows in 1995 in Tel Hadya, Syrian Arab Repubic, and in 1996 in replicate field trials at Tel Hadya and Breda, Syrian Arab Repubic. Marker data and field data were analysed with PLABQTL for QTLs. The analysis revealed, for powdery mildew, a QTL explaining about 15 per cent of the variation. This indicates a possible quantitative inheritance of the powdery mildew resistance. The QTL has been located on chromosome 1S near marker M2197. The QTL was stable in Tel Hadya in 1994 and 1995; therefore, the mean of the powdery mildew evaluation also showing the QTL indicates the same amount of variation. Further genome intervals contribute only a little more to the powdery mildew resistance. For *Rynchosporium secalis*, a QTL has been identified linked to the additional linkage group link 1. This QTL explained between 25 and 31 per cent of the variation between the two different testings. With a high LOD (logarithms of odd likelihood) score of 30 and 34, respectively, it can be concluded that a major gene is involved in the resistance at this locus. Further additional markers are necessary to integrate the additional linkage group link 1 with the seven available linkage groups.

TABLE 2. MARKERS SHARED BY THE TWO POPULATIONS AND THEIR ASSIGNMENT TO LINKAGE GROUPS

	Chromosome							
Mapping populations	1H	2H	3H	4H	5H	6H	7H	Total
T/WI and I/F (T/WI and I/F represent Tadmor * WI2291 and Igri * Franka, the prefix c indicates cDNA-clones, a, b and c after the number indicate the first, second or third largest fragment of the clone after hybridization)	MWG 837 2077 c649b 912	MWG c682 878 858 950 949	MWG 584 571a 96	MWG 2033	MWG 502 522 533 602 891	MWG 916 951 934 514 2053 10c	MWG 832 836	
Total	4	5	3	1	5	6	2	26

III.4. *Use of specific PCR primers for durum wheat improvement*

The durum agro-industry in the Mediterranean region, particularly in the WANA region, emphasizes gluten strength, in order to process pasta, burghul and couscous products. Durum wheat seed storage proteins, gliadins and glutenins, are largely responsible for gluten strength. Specific gliadin and glutenin protein bands are strongly associated with the quality of the gluten. Gliadin gamma-45 and its allelic form gamma-42 are biochemical markers for strong and weak gluten, and they are associated with low molecular weight (LMW) type 2 and LMW type 1 glutenin subunits respectively. Seed storage protein electrophoretic analysis for gliadins and glutenins are routinely used at ICARDA headquarters in Aleppo, Syrian Arab Repubic (ICARDA, 1996). PCR primers for glutenins (type 2 and 1) and primers for gamma-gliadins (45 and 42) were developed at the University of Tuscia, Viterbo, Italy. PCR-amplification by using these specific primers for gamma-45/42 and LMW-1/2 has been adopted as a new tool to select for pasta quality in the durum-breeding programme. PCR products were ectrophoretically separated on 1.2 per cent agarose gels and stained with ethidium bromide. PCR-amplification for LMW glutenins shows two fragments: one fragment being specific for LMW glutenin type 2 and for LMW glutenin type 1. The specific fragment is 50 bp (base pairs) longer in the case of glutenin 2 than for LMW glutenin type 1. In heterozygous genotypes, both bands for LMW-glutenin 2 and LMW-glutenin 1 are present. The advanced durum yield trials (ADYT) of 1994,1995 and 1996 were analysed with these PCR primers. The screening of 380 lines from ADYT 94, 240 lines from ADYT 95 for gliadin show that more than 89 per cent of lines have gliadin-45, less than 10 per cent have gliadin 42 and 2.5 per cent of lines are heterozygous. For glutenins, the screening of the same ADYT shows percentages similar to those of gliadin. The screening of ADYT 96 for glutenins shows results similar to those for ADYT 94 and ADYT 95. A total of 88.9 per cent of lines have genotypes with good quality, less than 8.7 per cent of lines have genotypes with poor quality and 2.4 per cent were heterozygotes. These results show that more than 90 per cent of lines cultivated in this area have genotypes with low molecular weight glutenin 2 and gliadin 45. This is a result of intensive selection conducted for many years. The use of white glumes as a selection criterion in the field, a closely linked morphological marker, as well as the storage protein analysis in the quality laboratory, is applied in our programme.

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R and D on Arabization of information technology systems*

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Introduction

Integration of work, culture and technology will be the key issue in the twenty-first century. Information technology (IT), coupled with communications, is becoming one of the most important industries. It is characterized by high added value and is a tool used in most of our activities today, with a multiplier effect on its productivity. The ESCWA member countries could have a share in this important industry, especially in software. They also have to use this tool in different areas, including management, automation, research and trade.

The multimedia computer deals with text, speech and image. Man-computer communication is very much language-dependent; therefore, full and efficient use of this tool by any country requires that this communication be in the language of the country. Arabization of IT is a prerequisite to the success of its introduction in the home, school, factory, and transport facilities of the ESCWA region.

There are different levels in Arabizing IT. The first deals with the standardization of character coding for storing, displaying, printing, and communications. The second is accessing system software in Arabic, such as operating systems and system tools. The third concerns the Arabization of application software, including office packages, scientific and commercial programmes, management software, and CAD (computer-assisted design) tools. Another related issue is the design and production of software packages treating Arabization itself, namely automatic translation into and from Arabic, terminology databases, computer dictionaries, and natural language understanding (NLU). Finally, there is the activity of elaborating and producing, in Arabic, information databases, information in all fields of knowledge on electronic support such as CD-ROM (compact disc read-only memory) or (on line) over computer networks. To find the most appropriate solutions to these issues, an important effort in R and D is needed, particularly in language-intensive applications. Some of these applications involve text and speech.

A prerequisite to addressing such issues is an intensive and large-scale R and D programme on Arabization, natural language processing (NLP), computational linguistics, speech analysis synthesis and recognition, and standardization.

However, such a programme cannot be realized by one or two ESCWA member countries alone. Cooperation and coordination are essential to the achievement of such a programme. Networking between R and D laboratories working in this area is one mechanism that can achieve this goal.

The ESCWA member countries have a substantial potential that can help them to succeed in this programme, because they dispose of human resources with regard to the Arabic language, and they have a rich heritage covering all aspects of Arabic both written and spoken.

Missing this opportunity currently before us could mean losing an important market and hindering the region's economic development by depriving it of an essential tool characterized by a multiplier effect.

R and D on information technology Arabization

Although there are several laboratories working on IT Arabization issues in the ESCWA region, both in the public and private sectors, the field is still very far from realizing its market potential. The Arabization of IT is a multidisciplinary field, involving specialities as varied as informatics, linguistics and electronics.

Different laboratories in the ESCWA region started working in this field in the late 1970s and the beginning of the 1980s. Examples of such early involvement are the cases of NCC in Iraq, KISR in Kuwait, the IBM (International Business Machines Corporation) centre in Cairo, and the IBM centre in Kuwait, SSRC in the Syrian Arab Republic, KACST (King Abdulaziz City for Science and Technology) and KFUPM (King Fahd University of Petroleum and Minerals) in Saudi Arabia, the Royal Scientific Society (RSS) in Jordan, and the Al-Alamieh company in

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Kuwait, in addition to several universities in different countries of the region. Some important work has also taken place in other organizations, in particular the Institute of Study and Research on Arabization (ISRA) in Morocco, CNI (Centre National d'Informatique) of Algeria and CNI of Tunisia, in addition to several companies in France, Canada, the United Kingdom and the United States.

A lot of effort in the early stages was concentrated on finding optimal solutions to Arabic character coding. Cooperation between ASMO (Arab Standardization and Metrology Organization), ECMA (European Computer Manufacturers Association) and ISO (International Organization for Standardization) was very important for the establishment of Arabic and international standards such as ASMO 449, 662, 708 as well as ISO 9036 and ISO/IEC 10646. With the introduction of intelligent terminals, microcomputers and the adoption of the contextual analysis technique, great strides forward in IT Arabization were made.

In the 1980s some R and D in computational linguistics and natural language processing was conducted by several laboratories, mostly in universities and software companies such as Alis (Canada), Al-Alamieh (Kuwait) SEDCO (Systems and Electronic Development) [Jordan] and Microsoft (United States). In the 1990s the essential R and D on IT Arabization has been conducted in private companies with the goal of commercializing certain products.

In computer networking, a number of projects were proposed to cover totally or partially the ESCWA region, or the Arab world. The most structured project is that adopted by the Arab League Documentation Centre (ALDOC); the project was called ARISNET. This network has three components, which are: the National Information Networks (NIS-NET), the Sectoral Information Networks (SIN-NET), and the Regional Information Networks (SRI-NET). One sectoral network of ARISNET is the Arab Science and Technology Information Network (ASTINET). This network has three subregional networks, the GULFNET, the MAGHREBNET, and the MASHREQNET. The ESCWA region is covered by two of these networks: the GULFNET and the MASHREQNET. The GULFNET is active now and is an important element in the communications between R and D laboratories of the Gulf region; it is connected to other international networks and has access to hundreds of databases.

RITSEC is a Regional Information Technology centre located in Cairo, with the role of coordinating and promoting IT in the eastern Arab countries. It organizes regional training courses and has proposed two regional networks: RITNET for IT and TRADNET for trade.

The issues of computer network communication in Arabic are mainly those of standardization. Although industrial and international organizations are adopting code-independent and bit-oriented (that is, language-independent) networking standards, companies are still developing important systems that are character-oriented, such as those that use start/stop bits. Another example is the electronic mail system MMDF (multimedia message distribution facility), which works under SCO-UNIX for text transmission. This system employs 7-bit coding (ASMO 449) which is not compatible with its Arabization program, which uses 8-bit coding (ASMO 708). Furthermore, we are witnessing the recent introduction of higher networking levels with communication services that employ artificial intelligence; this situation necessitates the development of Arabic communications layers and services. These services would not be transparent since they are language-dependent. Great efforts must be made in R and D to Arabize communications services such as VideoText, e-mail and EDI (electronic data interchange) as well as structured languages such as HTML (hyper text markup language), JAVA and SGML (standard generalized markup language).

Several computer societies have been set up in different countries of the ESCWA region such as:

- The Egyptian Computer Society;
- The Scientific Syrian Informatics Society;
- The Lebanese Professional Computer Society;
- The Saudi Arabian Computer Society.

These societies are interested in promoting R and D in Arabization of IT and standardization of the use of Arabic in computers and networks. Private sector companies are members of such societies. Usually, these societies have their own computer networks; therefore, promoting the connection of these networks could be very rewarding.

Most of the current R and D efforts in IT Arabization are aimed at the development of commercial products, are not very profound, and are limited to applications in the management domain. On the whole, R and D on IT in the ESCWA region is still dispersed and limited. Taking into consideration the complexity of IT, Arabization and the limited human and financial resources available, cooperation between the teams working in this area is essential and would add synergy to their results.

Major R and D issues in information technology Arabization

If the ESCWA member countries do not become involved in the information industries at large, they still have the opportunity to assume full responsibility for, or at least participate in, the development of the Arabic language-related information industry, since they have a competitive advantage in this sector. (The table below, although is not up-to-date, shows the relatively limited Arab share in one of the activities of the IT market table.)

Table. Where the programmers are			
Software developers and their managers by countries in 1990			
Country/ area	Programmers	Managers	Total
United States	1 693 200	253 980	1 947 180
Soviet Union	1 445 000	216 750	1 661 750
India	1 252 500	187 875	1 440 375
China	990 000	148 500	1 138 500
Japan	850 000	127 500	977 500
Germany	505 600	75 840	581 440
Indonesia	460 000	69 000	529 000
Brazil	441 000	66 150	507 150
United Kingdom	370 550	55 575	426 075
Italy	365 400	54 810	420 210
France	364 000	54 610	418 600
Mexico	261 000	39 150	300 150
Republic of Korea	236 500	34 475	271 975
Spain	234 000	35 100	269 100
Thailand	196 000	29 400	225 400
Turkey	192 500	28 875	221 375
Poland	190 000	28 500	218 500
Canada	169 000	25 350	194 350
Egypt	137 500	20 625	158 125
Taiwan Province of China	116 000	17 400	133 400
Total	10 469 700	1 567 465	12 040 400

Source: Software Productivity Research.

Some of the R and D topics involved are the following:

- Natural language processing;
- Natural language understanding;
- Automatic translation;
- Automatic text and speech retrieval;
- Text and speech compression;
- Machine dictionaries;
- Optical character recognition;
- Speech synthesis and speech recognition;
- Computer-aided education;
- Standards and terminology for IT.

Successful R and D in these fields would improve the multimedia man-machine interface in Arabic and make it more acceptable and efficient, thus promoting its dissemination in the ESCWA region. Furthermore, this is expected to have an impact on the economic, social and cultural development of the region.

NATURAL LANGUAGE PROCESSING

Most information deals with natural languages; NLP is usually an essential part of any sophisticated information system. R and D on NLP is concerned with the study of the behaviour and exploitation of natural languages by different approaches, which can be classified as either statistical or analytical. This research aims at simulating the analysis and synthesis of a language, and the designing of a computer system capable of producing an acceptable version of the language.

The complexity of this problem led researchers to use artificial intelligence techniques such as knowledge bases and expert systems. It is generally accepted that a splitting of the language system divides it into different levels. Among those levels are the phonetic, morphological, syntactical, semantic, and pragmatic levels. Another element is the lexicon, which constitutes the backbone of all these levels. For Arabic, each one of these levels is a vast field of research by itself, and cannot be exhaustively investigated by one team; cooperative R and D is needed in order to achieve successful results and products.

NLP is a necessary element in many IT applications, including machine translation, natural language understanding, man-machine communications and advanced automatic knowledge retrieval.

Several R and D organizations are working in the field of NLP on the major languages of the world. For Arabic, a few systems are available for the morphological level only (Morocco, Egypt, Syrian Arab Republic, Kuwait and IBM). Limited results are available on the syntactical level, but little comprehensive R and D has been carried out on the other levels.

Text and speech compression

Written language is redundant, and speech is still much more redundant. Consequently, storing information in memories, disks, CD-ROMs, or transmitting information, will be more efficient if we can reduce this redundancy. Text and speech compression techniques are cost-effective in applications where a large volume of information is involved. It can easily be shown that redundancy in Arabic texts is about 16 per cent at the character level (first order) and can reach 80 per cent at word levels. Reported research on Arabic text compression showed techniques with compression rates varying from 30 per cent for the bigram method to more than 70 per cent for morphological methods. No standard technique has been established yet for Arabic.

Speech compression techniques are much more complicated, and compression could reach theoretically as much as 1/1,000. These techniques involve speech production modelling, and can be language-dependent. Therefore, R and D on Arabic speech compression is necessary in order to work out an efficient standard technique; otherwise algorithms developed for English would be adopted and would not be efficient.

Natural language understanding

NLU can be defined as the process of mapping a written language for some internal representation appropriate to a particular situation. The understanding of the text is achieved by employing lexical, morphological, syntactical, semantic, and pragmatic knowledge of a language. Expert system techniques are necessary to handle the complexities involved.

When NLU is combined with speech recognition, hand-free speech control of machines is possible, thus leading to the possibility of innumerable applications. These has been little R and D in NLU of Arabic.

Automatic translation

It is well known that translation is an important factor in development: the availability of information, including information on science and technology, in the mother tongue can help in its rapid dissemination by removing the language barrier.

Translation is expensive and time-consuming. Automatic translation or machine translation (MT) is a solution to this problem. It can be employed to enhance global trade, especially if it is coupled to systems such as speech recognition and EDI. MT makes use of NLP: it starts with the source language and performs an analysis, then it uses NLP of the target language to perform a synthesis. MT to and from Arabic is active mostly within private software companies. There are already a few commercialized products, but they have not yet been completely perfected. Examples of Arabic MT products available are: Systran, Automated Translation Solution (ATS) from the Alis company for web pages and web site translations, TranSphere from AppTek, and other systems from ATA Software and Al-Alamieh-Sakhr. Since R and D in MT has not yet produced satisfactory solutions, computer-aided translation (CAT) is a step towards MT.

An international conference on MT is organized yearly by the International Association for Machine Translation (IAMT), which cooperates with three other regional organizations: the Asian-Pacific (APAMT), the American (AAMT) and the European (EAMT). ESCWA member countries need to have a network to link their efforts.

Automatic text and speech retrieval

Information retrieval has been improving for the past five decades. It was one of the main motivations behind the invention of the computer. Techniques in this field began with document retrieval, using paper-supported filing systems, and then microfilm- and microfiche-supported systems. The next development was computer data retrieval, which progressed to text retrieval and finally to knowledge retrieval. The knowledge retrieval process is language-dependent and needs several elements of NLP. R and D in knowledge retrieval is currently very intensive because of the increasing spread of electronic archiving, and because of its potential when made available on computer networks globally. R and D on knowledge retrieval in Arabic is scant.

There is now a greater need for the retrieval of speech documents, especially since the introduction of the multimedia microcomputer. This need for retrieval of speech documents is equally great for hypertext documents that include speech. R and D in this area is active and more complex than the work on text.

Optical character recognition

Optical character recognition (OCR) is a technique that transfers a written page from image format to coded character format. This means that pages of printed documents can be scanned by computer as images, and the OCR algorithm recognizes the characters and stores them in coded text format as if the text was entered though the keyboard. OCR is becoming an essential tool in the process of "going digital" in the main libraries of the world. These libraries use OCR to shift their huge archives, comprising millions of books and documents, from paper to digital support in order to make them available on-line for computer networks. This software is commercialized in several languages, and often attains a 99 per cent correct recognition rate. However, this still means that there are about 5 to 10 wrongly recognized characters in a page, and correction is done manually on the computer, using word-processing programs.

OCR products are available on the market for Arabic, but the recognition rate is still not high enough, especially for the large variation of character fonts in Arabic. A few laboratories have been conducting R and D on Arabic OCR in Egypt, the Syrian Arab Republic and Tunisia. Reliable omni-font OCR has not yet been perfected in Arabic, and handwritten character recognition is still more complex than printed text. Thus, coordination of research on these algorithms can help to accelerate the availability of high-scoring and cost-effective products.

Speech synthesis and speech recognition

Speech is the most natural means of human communication, and represents man's highest channel of information transmission. Multimedia computers use sound as one of their media. The world market in spoken man-machine communication (MMC) is increasing. There are many applications of free-hand MMC in: household appliances, voice warning systems, voice data-entry reservation, voice actuated access control, automatic typewriter, automatic information system inquiries, and automatic spoken language translation.

Arabic is spoken by more than 200 million people, who represent a potential market for MMC. R and D activities in this field include two major types of speech-processing, namely: electronic speech synthesis, (ESS) and electronic speech recognition (ESR). ESS is the production of spoken messages from a parametric transcription of them, while ESR is the production of a written message corresponding to its spoken version.

R and D on ESS has achieved well-established results for the major languages of the world. Different techniques and methods exist. In Arabic, laboratory prototypes have been reported, and a few versions were marketed recently.

ESR is a much more complex problem than ESS, and one can distinguish three axes of R and D in this field:

(a) Limited vocabulary single speaker systems, which are the simplest and could be language-independent; some Arabic products of this type exist;

(b) Large vocabulary multi-speaker systems, which can recognize thousands of words spoken by several speakers. Such systems require a learning phase in which the user has to start by speaking a certain number of words to enable the system to analyse his or her voice and tune to it. No Arabic software with an acceptable score of recognition is available yet;

(c) Continuous speech recognition, which is the most complicated type. No commercialized product of such a system has been announced yet, and R and D is very active in this area.

Computer dictionaries and terminology databases

Considerable efforts have been deployed in the area of IT terminology and dictionaries. One statistical study counted more than 126 references in Arabic IT terminology throughout the Arab world, which included 94 dictionaries. It is clear that the problem in IT Arabization is not in finding the terms, but rather in unifying their use throughout the Arab world.

Arabic computer dictionaries, if available, have the potential merit of helping the efforts of coordinating Arabization. These dictionaries can be made available on computer networks, both national and regional, and thus would help to spread, unify and update terminology. A number of projects in this area have yielded computerized databases in several Arab countries:

- BASM, which is an important encyclopaedic dictionary of computer terms, developed at King Abdulaziz City for Science and Technology in 1994;
- LEXAR, which is a terminology database developed at the Institute of Study and Research on Arabization in Morocco;
- The terminology database established by the National Institute of Standardization in Tunisia;
- The data bank of terminology developed by the Arabic Language Academy of Amman.

However, there are more than six commercialized computer bilingual simple dictionaries.

A fully developed computer dictionary could be very sophisticated, with lexical, phonological, phonetic, morphological, syntactic, semantic, and pragmatic capabilities. It can also incorporate historical information on each entry. This is a huge Arabization project in IT.

Computer-assisted education

One important IT market in the ESCWA region is computer-assisted education (CAE) edited in Arabic. The experience of software companies in the region has proved this. In addition to its commercial relevance, CAE has the merit of improving and promoting literacy in science and technology. Relatively substantial work in this area is being realized in Arabic. Ministries of Education, software houses and regional organizations are examples of parties promoting CAE. It is expected that this application of Arabized IT will flourish, but its scope of production must cover all fields of education, especially science and technology.

Quality assurance of Arabized information technology

Arabization of IT, including R and D, deals mostly with software development. Unfortunately, not all the work being done follows quality and reliability norms and measures, because of certain regional specific problems. Problems concerning IT Arabization can be summarized as follows:

- Many propositions rest on local levels and are not standardized as regional;

- The absence of Arabic standards and the demand of the market forces large companies to commercialize systems that have not been thoroughly studied, and thus unfortunately, they become the de facto standards;

- The non-enforcement of copyright property laws makes the establishment and growth of local software companies very difficult and unprofitable, and consequently local R and D does not enjoy private funding;

- There are no national or regional institutions with a mandate to organize software activities and ensure standards, testing and validating of software for quality and reliability. This situation results in the creation of small and not fully professional software companies that flood the market with cheap, non-reliable software without any quality assurance. This market atmosphere is not favourable to companies developing high quality products supported by sound R and D backing;

- Few IT companies in the ESCWA or Arab region practise advanced marketing policies and, as a result, local expenditure on advanced R and D are not likely to be paid back or recovered. Furthermore, R and D projects are duplicated in several countries of the region and even, many times, in the same country;

- There is a widespread belief in the region that, in buying information systems, it is the hardware that is worth the price, and not the software since the latter is not tangible, and the non-enforcement of copyright laws aggravates this problem;

- Frequently one can note that results of ITR and D are often not followed up;

- The use of software engineering supports such as management practices and tools has not been sufficiently introduced in the IT Arabization process.

Software development is no longer an art as it used to be; it has now been established as a science with its own methodologies and laws. Program writing has become a structured process. In order to focus R and D in IT Arabization, the following quality criteria should be satisfied:

1. Reliability: the frequency with which errors occur in a system: the lower the frequency the higher the reliability;

2. Stability: the frequency of changes to the structure and/or operation of a system: the lower the frequency, the higher the stability;

3. Recoverability: the ease with which a recovery can be made following the occurrence of an error;

4. Efficiency: the ratio of useful work done to the effort expended;

5. Availability: the ratio of the time the system is operational to the time when it is inoperable;

6. Learnability: the ease with which a system can be understood;

7. Modifiability: the ease with which a system can be changed;

8. Security: the extent to which a system is accessible to outside agencies;

9. Transparency: which ensures no differences when the user changes from English to Arabic and vice versa;

10. User friendliness: which requires no complicated manoeuvring because of bilingualism;

11. Portability: which permits perfect and consistent operation of the Arabized software

in different computer environments or platforms;

12. Multilingualism: which enables the user to process text composed of several languages at the same time;

13. Conservativeness: which preserves the particularities of the Arabic language.

Conclusions: enhancement of R and D in Arabizing information technology

We have entered the era of the information society, a society driven by new technology, a technology that has turned the world into a global village, opening markets and freeing competition. The engine of growth in the information society is powered by information and communication technologies, which:

- Speed innovation in all sectors through better access to timely information, better communications with co-workers, and better development tools;

- Generate new products and services and novel employment opportunities in new markets;

- Enable new and more effective methods of organizing businesses and manufacturing, bringing down costs and reducing wastage.

Arabized IT has a very important potential market, and the ESCWA region has a competitive advantage in this market for obvious reasons. Arabized IT products have high added value, and are generative with a multiplier effect. Furthermore, IT industries do not need large capital investment, and are environmentally sound.

Innovation is the lifeblood of industrial development, and particularly so in the case of IT. Technical innovation in Arabized IT can only come about through investment in R and D. Although R and D in IT Arabization are being carried out in both public and private organizations, targeted solutions have not yet been fully perfected, and many essential issues have not been addressed at all. Over the next few years, a redoubled effort at all levels of the R and D process will be as essential to economic growth as the ready availability and free movement of capital, the deregulation of world trade and global détente.

The R and D issues in IT Arabization are vast, complex, and multidisciplinary. We are not going to list here the well known recommendations for the enhancement of R and D in general, and we are not proposing another huge cooperative project to add to the many already proposed, but we would like to point out an accessible coordination activity that makes use of existing resources, namely networking.

We mean by networking the creation of links between researchers, developers and organizations that are active in Arabizing IT in the ESCWA region. The short-term aim of these networks is to promote coordination and cooperation in R and D on IT Arabization. The medium-term aim will be to seek legal and financial support for these efforts while consolidating these links and finally, in the long term, to build networks of excellence. These links can be built gradually and grow step by step in response to the demand, needs and financial support of the network. The media of communication between the members of these networks could be one of the available possibilities, namely the Internet, fax, or mail. Networks can group R and D teams and individual researchers, preferably according to the subject of interest in IT Arabization. Such subjects have been noted above in this paper. Another type of network can be created to regroup organizations having similar interests. Examples of such organizations are computer societies in the Arab countries that already have their local networks, IT companies in the Arab countries to coordinate pre-competitive R and D, and computational linguistic organizations to ensure that the same projects are not repeated in their programs. Examples of the activities of the networks could be the following:

(a) The creation of news groups on the Internet;

(b) The exchange of information;

(c) Discussion of R and D programmes to avoid duplication of efforts;

(d) A periodic publication disseminated by the Internet, fax and/or mail;

(e) The exchange of software;

(f) Dissemination of pre-competitive knowledge;

(g) The creation of business alliances;

(h) Cooperation with the Arab Scientists and Technologists Abroad (ASTA).

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R and D in information technology in the Syrian Arab Republic*

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Introduction

Research and development in the field of information technologies in the Syrian Arab Republic started somewhat late (in the 1980s) since the country's adoption of these technologies was delayed by many factors, mostly economic and social. Since then, many steps have been taken in the direction of building the infrastructure: communication lines, and physical networks are being built, with more and more institutions becoming aware that information accessibility is a key factor in improving efficiency.

With regard to computers in education, computer courses have become compulsory in all disciplines, and commercial/scientific curricula of secondary schools include informatics. The number of computers in the educational system remains limited, however, (nearly 2,000) but is increasing rapidly. Moreover, HIAST (the Higher Institute of Applied Sciences and Technology) has established itself as a leader in the Syrian Arab Republic. HIAST was the first institute of higher education to start a computer engineering programme 15 years ago, and to combine R and D with teaching [Mra95].

Administrative and managerial applications (including office automation and management information systems [MIS]) are predominant in the use of IT: 80 per cent of the computer market is geared to such applications. However, engineering applications, automation and control as well as CAD/CAM are becoming common.

A national data communication network (Syriapac) was established seven years ago and is used by several institutions for data transfer and for building distributed information systems. Although a latecomer to this field, the Syrian Arab Republic is soon to be connected to the Internet with a main node at the Syrian Telecommunication Establishment, which is going to be the sole Internet service provider for a trial period. Databanks are very few, but should multiply with the introduction of the Internet.

The widespread use of computers and related technologies requires engineering and development efforts, mainly in Arabization, software engineering, industrial automation and networking. It is obvious, however, that many more steps have to be taken to reach an acceptable level in the use of IT by international standards, before R and D can follow suit. In order to achieve this at an accelerated pace and in a coherent fashion, it is felt that a national strategy is needed to guide the public and private institutions in their quest for developing IT in the Syrian Arab Republic [Far96].

The computer market size in the Syrian Arab Republic remains small compared with the four neighbouring countries, but is expected to grow and expand rapidly during the next three to five years. Expected expansion in the field of education by itself is relatively large, since there are 989 general secondary schools plus 954 technical and other secondary schools to be equipped with PC (personal computer) laboratories within the next three to five years. Moreover, the four universities in the Syrian Arab Republic currently possess no more than 100 PCs for teaching purposes. In comparison with Jordan, which has about 10,000 PCs in its educational institutions, or with Egypt, which has tenfold that number, the Syrian educational PC market must evolve rapidly to catch up with neighbouring countries.

Furthermore, between 5,000 and 6,000 PCs come into the Syrian Arab Republic legally per year, while a similar number are assembled locally from spare parts. Thus, as a first indicator, about 10,000-12,000 PCs are sold annually on the Syrian market, compared with a similar number in Jordan, which has a much smaller population. An increase of about 30 to 35 percent per year is expected during the next three years, taking into account the various computerization efforts by banks, power companies and industries, and at all levels of education, as well as the introduction of the Internet.

However, the number of programmers and software developers in the Syrian Arab Republic with formal education or training does not currently exceed

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2,500, while in Jordan there are about 4,000 programmers and software developers. It should be noted, however, that the number of people practising programming and software development exceeds 5,000, and an increase of 20 per cent per year is expected over the next three years. The potential for growth should increase quickly as the Syrian economy becomes more open.

One major reason for the limited computer market in the Syrian Arab Republic is the low salary scale in the public sector. This seems to make a PC costly compared with the salary of a clerk/secretary, and furthermore requires higher qualifications for the user. This attitude is changing thanks to the informational programmes carried out in many public establishments, while computer literacy is becoming a requirement for many positions in the private sector. Another reason is the limited export market for Syrian software, which does not meet the quality requirements for international standards. This situation is also changing since ISO 9000 standards are becoming a necessity at the industrial level, and the need for an agency which would provide information about quality standards, train, and certify/enforce quality products is becoming greater every day.

The current R and D situation in IT in the Syrian Arab Republic is described below, with the focus on the obstacles and existing problems. Taking into account the European approach for the promotion of research in IT, efforts and proposals are then presented that should help to remove obstacles and increase the chances of success of IT research projects in the country.

1. Current status

In a report presented to ESCWA [Far97], specific R and D projects were analysed and evaluated. Some of them are E and D (Engineering and Development) rather than R and D projects, and indicate a certain level of maturity in the IT research community in the Syrian Arab Republic. They include the following projects: advanced traffic controller, Damascus water network information system, management of telecommunication operations, multimedia archaeological information system, Arabic optical character recognition, expert system for the Arabic language, Arabic research-based computerized curriculum, Arabic information retrieval system, and CAD/CAM for brocade.

The analysis of these various concrete experiences revealed positive and negative aspects the presentation of which gives a good idea of the current status of R and D in IT. Positive aspects include those listed below.

(a) Most of the research being carried out is oriented towards real and practical problems with products in mind. Thus, it may seem quite often to be more in the nature of advanced engineering work rather than R and D. However, notwithstanding the importance of theoretical research, this approach is a reasonable one for a developing country with few qualified human resources in IT.

(b) The main IT areas in which research and development are needed, and in which there is a nucleus of competent researchers, are: automation and control, CAD/CAM, multimedia, processing of the Arabic language (including AOCR [Arabic optical character recognition]), software tools and methodologies, and various application software.

(c) The proportion of female researchers and developers in IT is around 15 per cent, and they play a leading role in some projects. Moreover, there is no prejudice among their male peers, and they are encouraged by their supervisors to increase their contribution.

(d) Most of the R and D in IT is carried out by two institutions, one research centre (SSRC) and one institute of higher education (HIAST). The reasons are obvious: SSRC is mandated to do research, and HIAST has budgets for research, a low teaching load (six hours/week on average), and higher salaries than the universities (more than double, with many fringe benefits). In addition, some graduate students are completing part of their research work at HIAST while being registered in a European university.

However, the following problems were noted and need to be addressed:

(a) Very little research in IT is being carried out at the universities. The main reasons are: (i) the high teaching load (about 16 hours/week), which reduces the time for research; (ii) the low salaries of the teaching staff, which makes them look for sources of income other than research; (iii) the lack of specific budget and facilities for research; and (iv) the lack of graduate students and graduate studies. Professional Work Units were established to encourage research under contract. However, there is practically no supervision on the part of the universities (which request only their 18 per cent commission on every contract signed by any one of these units). Consequently, most of the work done by these units in IT is of ordinary engineering level.

(b) There is no R and D in IT in the private sector. The private sector, and primarily the industrial sector, has started to develop and to modernize its technologies during the past six to seven years. This should eventually lead to the development of R and D in medium and large private enterprises.

(c) Collaboration among local IT institutions is weak. This is due to the heavy bureaucracy in most public institutions, to the traditional mistrust between public and private institutions, and to the difficulty of coordinating efforts among various partners. Computer communications and networking can alleviate some of these difficulties by permitting informal contacts and exchange of information. But a different way of thinking is also required on the part of management in the various institutions.

(d) Collaboration with regional and international institutions is poor. Except for SSRC and HIAST, if and when there is collaboration, it is generally at the national level. There are many reasons for this, the most important being the heavy administrative procedures involved in external collaboration, the lack of modern flexible means of communication (computer networks), foreign language difficulties (for international collaboration), and weaknesses in scientific and technological management.

(e) Weaknesses in marketing are great. There is a real need to associate R and D institutions with marketing enterprises with a product-oriented mentality, and preferably run by the private sector for more flexible and dynamic behavior.

(f) Weaknesses in management of R and D tasks are real. This is obvious from the various problems encountered in many projects, especially where there is multidisciplinarity. The generally young researchers in IT lack the experience needed in managing research teams, enforcing standards, and turning around difficulties encountered during the course of the project. Furthermore, specialized technological resource centres, which can be of great help in these situations, are non-existent.

(g) Lack of qualified IT research staff. The Syrian universities need to expand their IT facilities and produce more qualified engineers and would-be researchers in the various fields of IT. The number of engineers graduating from HIAST (the only high-standard technologically oriented institution of higher education) is too low to satisfy the needs of the country in the coming decade. This lack of qualified research staff causes delays in the completion of projects, leading to negative effects on their results, given the ever shorter product life cycle in high technology markets.

(h) Linkages between R and D institutions and application sectors require strengthening. They are essential for real R and D advancement in IT, and in spite of the fact that there are some links within the public sector, the user community is not fully aware of the existing potential for R and D in the country. Furthermore, very few linkages exist between the public sector and the private enterprises, although the former possess R and D institutions and the latter needs R and D results.

Many factors have led to the current situation, but the main one is mutual distrust. On the one hand, public sector R and D institutions limit contacts with the private sector to very narrow channels, considering such contacts as suspicious and almost illegitimate. On the other hand, the private application sector looks at R and D institutions of the public sector as bureaucratic, inefficient and unreliable, and avoids dealing with them as much as possible. This mutual distrust needs to be removed, and partnership between R and D institutions and private IT application enterprises must be promoted in order to build lasting links between IT researchers and users.

Even within the public sector and with the presence of formal links, the lack of user motivation can lead to the failure of R and D collaboration projects, by, for example, the withholding of information, the use of delaying tactics or by amplifying problems. It is of vital importance to make sure that users are motivated and willing to collaborate in any joint venture.

The technical and logistic measures required to further develop and reinforce links between researchers and users of these technologies include inter-institutional networking, the creation of common R and D enterprises specialized in IT fields, more flexible regulations, and less centralization in the decision-making process.

2. Initiatives for promoting research and development in information technology

Currently, there is no clear strategy or plan for IT development in the Syrian Arab Republic at the national level, let alone R and D in IT, although the importance of these technologies is generally recognized. Ideas for a proposal on a national programme and plan for IT development have been put forward by the leading professional society in IT, the Syrian Computer Society (SCS), but these ideas are still in the early stages of discussion and have not yet been developed enough to enable policies to be established.

Furthermore, since IT falls under Science and Technology (S and T), many of the problems noted in the section above are common to all S and T fields. A study was carried out on this subject in 1991, and it is useful to review those findings of the study that relate to R and D in IT, as well as the ideas presented by the leading professional society in IT, the Syrian Computer Society (SCS). The European approach to promoting R and D in IT is worth reviewing before putting forward and discussing a proposal for such an undertaking in the Syrian Arab Republic.

2.1 *Strategy for science and technology*

Most of Mullin's findings in his study carried out in December of 1991 [Mul91] are still valid today. One major finding was that much change is needed before the Syrian Arab Republic can claim to have an S and T system. Such a system should contribute to the national socio-economic welfare, and include mechanisms for the formulation of policies and plans, financing activities, execution of research programmes, linkage of R and D output to practical use and linkage to regional and international S and T activities, education and training, and should also contribute to maintaining the vitality of the scientific and technological community in the country.

Important findings related to the above study on R and D in IT are the following:

(a) The Supreme Council of Sciences, established in 1958, does not seem to be active in S and T overall policy-making on the support and application of S and T for the purpose of national socio-economic development, and no other body, organization or ministry is responsible for that area;

(b) It is impossible to determine exactly how much the Syrian Arab Republic spends on science and technology, but it does not go beyond 0.15 per cent of GNP;

(c) The financing of research at the universities comes from the main budget allocated to each university by the Ministry of Higher Education, and does not exceed 1 per cent of that budget;

(d) Weaknesses do exist (on both sides—researchers and users) in building linkages between R and D and production;

(e) Rules and regulations at (public) research centres lengthen the response time to outside requests;

(f) The research publication record seems dismal, and no official statistics exist to compare it with neighboring countries;

(g) On the individual researcher level, there is no motivation to do serious research.

In spite of the above, the study is optimistic regarding the development of such an S and T system, and sees opportunities to improve the situation by strengthening inter-ministerial coordination, creating "Industrial Clubs" and encouraging technology-blending.

A process has been proposed for S and T strategy development, with a Steering Committee at the level of the Prime Minister's Office, whose terms of reference should include: clear goals, new implementation and funding mechanisms, ways of improving the flow of information and of creating working linkages at the national, regional and international levels, as well as encouraging innovation, technical services and the widespread use of evaluation. This Committee would include representatives from key ministries, SSRC, universities, Chambers of Commerce, Industry and Agriculture, and professional societies.

2.2 *Information technology national programme*

The Syrian Computer Society has put forward a proposal for the promotion of IT through the establishment of a national programme. This proposal attempts to deal with current problems by suggesting short-term actions and measures to be taken as soon as possible in order to eliminate the delay in the IT field. Indirectly, it helps to promote R and D in IT by improving the basic conditions for its development. The main points presented in this proposal can be summarized as follows:

(a) Developing informatics programmes at the universities;

(b) Reinforcing informatics education in schools at all levels;

(c) Promoting informatics culture in all sectors of the society;

(d) Developing continuous education/training for information workers;

(e) Encouraging serious computerization efforts in all public services and establishments;

(f) Improving computer network access at the national level, thus creating a positive climate for networking and information exchange;

(g) Introducing Internet services into the Syrian Arab Republic since this international gateway is essential for the overall development of the country, and especially for the promotion of R and D in science and technology;

(h) Developing data banks at the national level;

(i) Encouraging the investment in and creation of small and medium-size enterprises (SMEs) in IT;

(j) Promoting the establishment of a local software industry;

(k) Promoting linkages between R and D institutions and end-users.

Together with this proposal, suggestions for specific tasks that should be executed by ministries and/or public institutions are given. A higher authority is considered necessary for the supervision and coordination of the various tasks of the programme. This authority could be a ministry or a commission with some executive powers linked to the Prime Minister's Office.

Whether a national programme based on this proposal will be adopted at the highest level in the Syrian Government remains to be seen. However, serious efforts are being made by SCS to accelerate the decision-making process with respect to this important and critical issue of IT promotion and development in order to avoid further delays.

2.3 *Proposals for the promotion of research and development in information technology in the Syrian Arab Republic*

Today's information technologies have a great effect on the socio-economic fabric of a country, since these technologies enter into all aspects of modern life and at an increasingly important rate. It is necessary for a country like the Syrian Arab Republic, in the context which has been described above, to start taking giant steps forward to reach the level of competency and advancement required to survive in the global information society of tomorrow.

The promotion of R and D in information technologies is a must, but can be sustained only if linked to the needs of the economy and if the necessary qualified human resources are made available. This means that there should be concerted efforts to promote IT in various sectors, in particular universities, research institutes and industry. Proposals for such promotion are reviewed below for each of the principal sectors concerned.

Government

In the Syrian Arab Republic, the Government plays a central and leading role in building the infrastructure and developing the society and the economy. Thus, appropriate legislation and directives are crucial in the promotion of IT, including R and D in this field. Without such catalytic legislation and directives, not much would change.

Consequently, an overall information technology strategy or policy should be adopted by the Government to move towards the information society of tomorrow, with clearly defined aims and objectives. A steering committee should be formed to define a plan based on this policy, which should be adopted by the highest executive authorities and implemented soon afterwards.

Such a plan should take into consideration many of the issues reviewed above, particularly budgeting for IT and for R and D; motivating IT end-users of the public sector; allowing and facilitating the flow of information (leading to data banks); encouraging SME investment in IT (leading to a software industry); and introducing full Internet services. Furthermore, the plan should, in the short term, strengthen existing R and D structures by giving them the means to develop their capabilities to the fullest possible extent. In addition, the plan could set up favourable conditions for creating linkages between R and D structures and the application sectors, as well as the establishment of IT resource centres. In medium-term planning, the establishment of a new IT-specific R and D institute within a regional context, as part of a network of complementary institutes in the region, should be envisaged.

A special commission, board, or even a State ministry could be in charge of supervising the execution of this plan and making the necessary interim reports to the Prime Minister's Office. Without such a strategy and plan, it will be extremely difficult to make any tangible progress in IT, with the technological leap-frogging required. This can only be achieved by careful planning and coordination between various sectors of the economy.

Universities/higher education

It is widely recognized that without adequately trained people there is no technical capability. Thus, in order to promote IT, it is essential that curricula (which should be good by international standards) become available in Informatics, Telecommunications, Automation and Control, and possibly other IT-related specializations, in most Syrian universities. Specialized departments and graduate studies in these technological areas should be established, and higher standards should be adopted for graduating students.

For the purpose of increasing links with industry and promoting research at universities, it would be useful to have teaching staff from industry and research centres. Furthermore, the boards of the concerned departments, or faculties, should include representative members from industry and from research centres who are actively working in IT. These representatives could have their say in the curricula being devised to make them adapted to the market-place.

In the current context, universities may have difficulties in controlling the technological level of the tasks performed by their professional units. A different policy should be adopted, whereby research becomes mandatory for the promotion of academic staff at all ranks, and special funds are set aside to pay researchers. Formal agreements with the industries could keep these funds active and encourage stronger links with the production and service sectors, thus maximizing the chances of success of R and D projects.

Professors at universities could also have lighter teaching loads (almost half the current loads) if they chose to do serious research and development. Their salaries should certainly be raised and a system of research grants established. Research units can also be created in a way similar to the professional work units with tougher conditions on the scientific and technological side (to make sure that the projects are really R and D projects), but with more lenient economic conditions (such as smaller commission fees to be paid to the university, or no fees at all).

In any case, professors doing research would have to submit to an evaluation to make sure they have a good R and D achievement record before they are promoted. Publications may be one criterion for evaluating the research that is being carried out; use and dissemination of results should be another; and collaboration with other researchers on the regional and international level yet another criterion.

However, advanced technological institutes, similar to HIAST and oriented to IT, should be established to set standards of excellence and produce the needed researchers, research engineers and technologists. They should have strong links with regional and international educational and research institutes in their capacity as members of networks of excellence.

One unique example that could also be considered in the medium term is the United Nations University/International Institute for Software Technology (UNU/IIST), located in Macau [Bjo94]. Such an institute aims at assisting developing countries in strengthening capabilities by working with cutting-edge universities, research centres and industries. "Master's classes" are established for participants to study state-of-the-art formal software development techniques rooted in design calculi, and then use them in their R and D work. The results have been very encouraging, showing the possibility of excelling in R and D training in developing countries, and setting the pace for similar experiences in other regions.

Linkage between R and D and application sectors

All sectors of the industry and all service institutions should be, or will become, consumers of IT in the very near future. Thus, they ought to be the main promoters of R and D in IT by bringing forward the problems they encounter and for which R and D institutions are able to find economically feasible solutions. Since most of these industries and services are small and medium-size enterprises, which cannot afford to set up their own R and D activities, agreements should be made with research institutes to carry out the needed research for them. It may even be feasible to have such agreements between Chambers of Industry or Commerce and research centres to cover a wide range of industries. Such an agreement exists today between SSRC and the Damascus Chamber of Industry.

In the medium term, mixed research units funded and staffed by universities and industry within the context of such an agreement would be feasible. They can be, in many ways, similar to those that exist in the European national context, that is, project/product-oriented.

R and D IT laboratories, whether in universities or in research centres, should become more open and market their potential on the national and regional fronts. Strong links with the local application sectors should make them address research problems that are required by domestic industries and services (hospitals, ministries and government agencies). These links need to be promoted by initiatives from the Government or its agencies similar to the initiatives taken by the European Commission for ESPRIT. Research funds would be set aside for supporting research projects oriented to solving problems of local enterprises and SMEs in particular.

Another way of promoting these linkages would be through IT resource centres covering the most important aspects of information technologies. Such centres should exist at the national level, but would also be useful at the regional level (such as RITSEC [Regional Information Technology and Software Engineering Centre] in Egypt). These centres would be the main vehicles for indirectly linking R and D institutes with application sector establishments. Their main functions would be:

(a) Technology transfer, including technological developments, training for IT industry, seminars on new and advanced aspects of IT, consulting and information services;

(b) Promotion of standards, including IT best practice, quality standards promotion and certification;

(c) Development of information technologies for business processes, in order to support the transformation of enterprises and make them more competitive in tomorrow's global information society;

(d) Alliances with regional and international resource centres, sharing information and cooperating on IT projects in the region through networks of excellence centres;

(e) Creation of links with local, regional and international universities and research centres through collaboration, partnerships and alliances with these institutes;

(f) Incubator for small businesses in IT, with information, guidance, consulting, or even space for newly established enterprises to enable them to "take off" in the best possible conditions.

Given the importance of software locally and regionally, a software engineering resource centre should be established. This proposal is reviewed below.

Collaboration between R and D laboratories

It is of vital importance to make various R and D laboratories in the IT fields cooperate, whether inside or outside the Syrian Arab Republic. Common R and D problems exist, and cooperation with other laboratories is an enriching experience and a necessary one when multidisciplinarity is required. It seems, however, that most individual researchers and establishments try to avoid such cooperation whenever possible. Individualistic tendencies, bureaucracy, distance, lack of networking facilities, and language barriers are among the main reasons for avoiding such cooperation.

Syrian research institutions are missing opportunities for financing R and D by shying away from collaboration with European laboratories. HIAST is the only institution that has been involved in EU-financed programmes such as MED-CAMPUS and INCO-DC. Its Internet link (through Egypt), the fluency of its researchers in both English and French, and its involvement in research projects have certainly helped to establish these links at the regional (with RITSEC) and international levels (mainly with French and European institutes).

Universities should therefore encourage and facilitate regional and international cooperation. They should get involved, through their research staff, in programmes like ESPRIT, INCO-DC (including KIT [keep in touch] activities), MED-CAMPUS, or other European and international cooperative programmes to develop their R and D capabilities and create an internal dynamism which is very much lacking today.

Networking at the national and international levels (Internet node in the Syrian Arab Republic, and country-wide modern communications) would certainly facilitate contacts between laboratories, thus making the implementation of common projects and multidisciplinary alliances and collaboration with regional and international institutions possible.

The EU approach to the promotion of collaboration between R and D institutes as it is implemented within the EU Framework Programmes, and more specifically in ESPRIT, is worth applying at the regional level. A call for R and D projects could be made by regional agencies, and candidate projects should have as partners R and D laboratories and SMEs. At least two countries in the region should be involved, and IT application-oriented enterprises, which are the users of these technologies, should have an important role.

Specialized technological resource centre for software

The Indian experience in software development, which made India a major producer and exporter of quality software in the world (Bha94), is a useful example for developing countries with a nucleus of highly qualified researchers and engineers. Software development is a human-intensive process that requires a high level of education and training. It can provide, through exports, a valuable means of earning foreign currency and create opportunities for small and medium-size enterprises. Moreover, local and regional markets are eager for application software that is adapted to local and regional needs.

Software has been recognized by many developing countries as a necessity for present and future development. However, in the Syrian Arab Republic, practical steps to ensure the construction of the infrastructure needed to evolve in that direction have not always followed that recognition. Training in software engineering should be intensified if qualified software engineers who can produce quality software products adapted to the needs of the application sectors are to become available. By making software engineering principles and paradigms widespread within the software development community, the quality of software is improved automatically. Furthermore, efforts should be made in the direction of Arabizing tools or adapting them to an Arabized environment.

Emerging software development enterprises are in dire need of information and guidance with respect to methodologies, tools, standards and markets. Thus, a technological resource centre in software is absolutely necessary to help to establish a healthy software industry. It would be advisable to give such a centre a regional perspective, by making it part of a network for similar national resource centres (see the box below).

A concerted regional effort in this direction is needed, since the requirements of the ESCWA member countries are similar and cooperation between several countries leads to more feasible projects, both at the economic and technical levels.

IT-oriented R and D institutes

None of the existing research structures in the Syrian Arab Republic today are IT-oriented. The research centres carry out general scientific research, and the teaching and research institutes (the universities and HIAST) also have a more general orientation. Once these structures are given the necessary means to do research and development in the IT field, and they start producing results, however, it would seem natural to take one step further and create research institutes dedicated to IT or important areas of IT. Two areas are suggested below: one covering several basic areas of IT, and the other specifically covering the software area.

R and D institute for information technologies

Such an institute is needed in the Syrian Arab Republic in the medium term. It should be independent of the universities, although strongly linked to them and to various research and training institutes. Alliances and collaboration with regional and international institutes with similar objectives are also required.

It should carry out R and D in important areas of information technology for the development of the country such as: automation and industrial control, CAD/CAM, multimedia, robotics, expert systems, telecommunications and networking, parallel and distributed computing, and information systems. It could be under the supervision of the Ministry of Higher Education (in charge of research), or of a new Ministry of State for IT (which would have the task of promoting IT in the country, including R and D).

Box. Specialized technological resource centre for software

A study was carried out under the auspices of UNIDO in 1994, and a strategy was proposed by a UNIDO expert for the establishment, in two phases, of a specialized technological resource centre [Mur94]. The main functions of such a centre would be:

(a) Development of indigenous software tailored to specific requirements and respecting local constraints;

(b) Customization and Arabization of selected software packages;

(c) Consultancy and advisory tasks;

(d) Training of various types, including training of trainers;

(e) Creating computer awareness, and spreading computer literacy;

(f) Participating in the elaboration of legal and financial foundations for a software industry, including copyrights and quality control (ISO 9000);

(g) Becoming a centre of competence and an information broker for IT;

(h) Identifying, monitoring and evaluating world trends in software technology;

(i) Running a vendor-independent showroom for state-of-the-art software and computer applications, and a software clearing-house;

(j) Incubation of small businesses in software;

(k) Cooperation with academic institutes and research centres in applying their R and D results and turning them into products.

A software research institute

The scant research that has been compiled in the Syrian Arab Republic, particularly at SSRC and HIAST, has been more and more oriented towards application sectors in which IT plays a central role [Arm95]. Moreover, software is identified as the area within IT that is most required, and in which extra efforts should be deployed, with high returns reflected in improved socio-economic welfare.

Thus, in the medium term, and once the software technological resource centre becomes functional, the maturity level of software development enterprises is expected to increase rapidly. This improved situation would require a research institute dedicated to software technology, with aims similar to those of the proposed R and D institute for information technologies reviewed above: the institute should be independent, but with strong links to local universities and research centres. It should also be part of a regional software R and D network in which similar institutes in the region should collaborate. Such an institute would certainly conclude strategic alliances and collaboration agreements with other regional and international software research institutes.

The main areas of software technology that seem to be of local and regional importance and in which R and D should be carried out include: Arabization of software and systems, Arabic language-processing, intelligent and multimedia information systems, AI (artificial intelligence) and expert systems, parallel processing, distributed computing, and cooperative systems applications.

3. Conclusions

IT in the Syrian Arab Republic is less developed than in neighbouring countries of the ESCWA region. Furthermore, Syrian research and development efforts in IT lag behind similar efforts in other ESCWA member countries.

In the information society of tomorrow, IT will be everywhere, and all developing countries should prepare themselves to deal with the new technologies. This will only be possible through R and D, which will enable countries to acquire and adapt the necessary knowledge, and to solve the various local development problems.

In a country like the Syrian Arab Republic, in which the public sector is dominant, and where regulatory directives play a major part in development, an important role has to be assumed by Government. Government should play a catalytic role in areas of major economic and social importance; IT is one of them. Thus, it is essential to promote existing small and medium-size IT industries and to help the new ones by establishing IT resource centres. Some of these should be oriented towards specific important areas such as software development.

The promotion of collaboration between various R and D laboratories in IT at the local and regional levels can be promoted by local agencies and regional organizations with a collaborative project funding approach, similar to the one used by the EU in ESPRIT.

Research and development in IT, with permanent linkages to industry, is a necessity for development today, as has been clearly demonstrated through the study of concrete experiences. In the near future, with the erosion of boundaries between academia and industry, it will become essential to have high-standard research institutes in information technologies and in key areas of IT such as software technology. Such institutes should have strong links with application sectors such as education and industrial and services sectors at the local level. They should also be part of networks, partnerships, and alliances at the regional and international levels comprised of R and D institutions with similar and/or complementary interests. Such networks will ensure that the institutes keep abreast of scientific and technological novelties and advances, and promote innovation and creativity in their fields of interest.

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Improving the effectiveness of R and D in water resources for sustainable development and resources*

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Abstract

During the past three decades, the demands for water for agricultural, industrial and domestic purposes in Saudi Arabia and many other countries in the ESCWA region have been growing rapidly owing to the increasing population and overall developments in the region. However, the limited water resources in the region cannot meet the rising water requirements in terms of quality and quantity. Consequently, the priorities, activities and institutional structures of R and D have been directed by the increasing competition for water resources on national, regional and international levels.

Several limiting factors have affected R and D success and applications. Among these are; (a) the lack of sufficient and high quality data needed for R and D programmes; (b) the lack of sufficient and effective linkages with water application organizations; (d) the lack of collective expertise and efforts on intra-institutional levels nationally and regionally; and (e) duplication of R and D efforts.

The regional international coordination between institutions in R and D on water resources has been confined to localized and limited R and D activities. Successful R and D efforts to optimize the use of the available surface water and groundwater from the aquifer systems, to upgrade the quality of the available water, and to improve the domestic and industrial wastewater treatment technologies requires effective models for networking and coordination on national, regional and international levels simultaneously.

The success of R and D results and applicability with regard to water resources depends on the availability of reliable data, teams with multidisciplinary expertise, national and international joint efforts using blended technologies, continuous upgrade of technical capabilities, and efficient linkage to the water producers, users and authorities. Inter- and intra-institutional networking on national, regional and international levels and contributions from professional organizations are important tools to help to secure the above requirements for successful and beneficial R and D in water resources. This paper addresses all the above issues and investigates their benefits for the efficient application of R and D on national, regional and international levels.

Introduction

Demands for water are increasing rapidly in most of the countries in the ESCWA region owing to population growth and overall regional developments. The availability of long-term water supplies to meet the demands, in terms of quality and quantity, is a major challenge [1], especially to the arid countries of the ESCWA region. Consequently, R and D plays a very important role in satisfying the demands for water through available conventional and non-conventional water resources.

There are several limiting factors that affect the success and application of R and D. Among these are: (a) the lack of availability of the required data for R and D programmes; (b) the lack of enough linkages with water application organizations; (c) the lack of collective expertise and efforts on intra-institutional levels nationally and regionally; (d) duplication of R and D efforts; and (e) the lack of an effective role and contribution of the private sector.

This paper reviews the above factors and suggests recommendations for efficient application of R and D on national and international levels.

The availability of the required data for R and D

The availability of the required water data for R and D is vital to the success of R and D applications at local and regional levels. Examples of these types of data are: (a) quantities and qualities of the available water from conventional and non-conventional resources; (b) current and expected growth in demands for water for different purposes in terms of quality and

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quantity; (c) comprehensive properties of water and wastewater; (d) water and wastewater facilities and networks; (e) weather data; and (f) hydrological and hydrogeological characteristics. The problems in obtaining these data are due to one or more of the following factors:

(a) Lack of the required financial support or expertise;

(b) Lack of reliable data collection techniques;

(c) Lack of effective linkages between data sources and R and D organizations;

(d) Lack of specialized offices or agencies for data;

(e) Lack of effective quality control procedures on the collected data.

Timely data collection is essential. It requires reliable techniques and specialized expertise, effective data compilation and quality control, in addition to direct links between data sources and R and D organizations on local, regional, national and international levels. The presence of a specialized office as a water data source on regional and national levels is also an important tool to provide the required data for R and D when required [2].

Linkage with water organizations

The links between R and D organizations and water application agencies and authorities, and water producers and users on local and regional levels are important in achieving successful use of R and D. Unfortunately, the required link channels are not enough and are not effective and, in several countries of the ESCWA region, are non-existent. Consequently, the benefits from any R and D efforts in water resources will be limited and not effective. To overcome this problem, professional and effective link channels and procedures should be established between R and D organizations and water producers, users and authorities on local levels. The link channels should be defined according to the type of R and D and its applications and needs with regard to various water organizations. International and regional organizations can play an important role in linking R and D organizations and other water authorities and users on regional and international levels.

Collective expertise and efforts on intra-institutional levels, nationally and regionally

R and D in water resources requires teams with multidisciplinary expertise, national and international joint efforts using blended technologies, and continuous upgrading of technical capabilities of various organizations. This objective cannot be achieved without effective and collective efforts and expertise on intra-institutional levels on a local, regional and international scale. Inter- and intra-institutional networking on national, regional and international levels and contributions from professional organizations are important tools to achieve successful and beneficial R and D to enhance water resources [3]. The success of the networking depends on its extent and the available expertise.

Duplication of R and D efforts

It is well known that R and D efforts invested in water resources are wasted and not effective owing to duplication of efforts. Sometimes, R and D teams come to know about the activities of other teams too late. Some teams do not know anything about the efforts of others. This is due to a lack of communication and interaction between researchers and research organizations on local, regional and international levels. To avoid wasted efforts because of duplication of R and D activities, several measures should be taken. One of the most important is to ensure the availability of effective communications between organizations and researchers on local and international levels. The recent revolution in communications through the Internet is a great help to R and D organizations on local and international levels. R and D programmes can benefit directly and effectively from the newly developed technologies in various organizations. Local and regional meetings, workshops, symposia, conferences and seminars are effective tools for communications. Specialized journals containing technical information about advancements in R and D are helpful in the transmission of R and D information.

Role and contribution of the private sector

The role of the private sector in carrying out R and D on water resources in developed countries has been very effective and helpful in solving major problems in water supply and treatment technologies. This role has not been noted in many countries, especially in the ESCWA region. This is due, among other factors, to underestimation of this role by businessmen and water authorities and users. A lack of incentives, support and encouragement from government authorities to the private sector is an additional reason that the private sector does not play an effective role.

The private sector can be motivated to assume its proper role in R and D and contribute to the expected benefits. Incentives should be given to the private sector to contribute to R and D in the field of water resources, focusing on desalination, wastewater treatment, and remediation technologies.

National organizations such as Chambers of Commerce can play an important role in making the private sector more aware of the value and commercial benefits of R and D in water resources. International organizations such as ESCWA and UNESCO can also play positive roles in orienting the private sector in different countries towards R and D in order to achieve successful and useful applications of R and D programmes. These organizations can also provide technical advice on the new technologies and furnish available expertise to the private sector.

Case-studies in R and D in water resources

During the past two decades, the Water Resources Development Section (WRDS) has been active in R and D in water resources-related fields in Saudi Arabia. Several R and D successes were recorded. For example, the implemented R and D in irrigation water management information systems for large irrigation schemes in different regions of the Kingdom helped to improve efficiency of water operation and use and to save more than 25 per cent on irrigation water consumed. Furthermore, R and D in industrial wastewater treatment and recycling helped to introduce new and effective technologies for large industrial plants. The implementation of these technologies helped to recycle about 95 per cent of the wastewater effluents, and to reduce groundwater pumping at factory level by 85 per cent.

Example 1: R and D for the development of an irrigation water management information system for a complex and large irrigation scheme using a multi-channel system.

Phase I: Development of a multi-channel network flow model for the Al-Hassa irrigation and drainage project.

Client: Al-Hassa Irrigation and Drainage Authority, (HIDA), Al-Hassa, Saudi Arabia.

Budget: 3.46 million Saudi Arabian riyals (SRls).

Duration of project: 1 March 1982-30 April 1984.

Summary of the study

1. The Al-Hassa network model is unique in its characteristics and functions in the world.

2. The development of such a model was a technical challenge to WRDS.

3. The WRDS used a multidisciplinary research team to accomplish the planned objectives.

4. The results of this study helped the Al-Hassa Irrigation and Drainage Authority to overcome the problem of an unsteady flow of water and to control and adjust the opening of hundreds of gates supplying the required water in the irrigation project.

5. The development and implementation of the hydraulic package, the Al-Hassa multi-channel network model, helped to optimize the openings of a large number of gates and to improve the control of the unsteady flow of water in a complex canal. The use of the developed model improved the efficiency of water operation in the irrigation network.

6. The model has an international value, and can be used in similar irrigation networks in the world after the initial conditions have been modified.

7. The model development is a great achievement for the KFUPM Research Institute in the areas of irrigation water operation and management. Several international organizations showed interest in the use of the developed model.

Phase II: Development of irrigation water requirement and schedule model.

Client: Al-Hassa Irrigation and Drainage Authority, Al-Hassa, Saudi Arabia.

Budget: SRls. 2.719 million.

Duration of project: 1 May 1984-19 April 1988.

Summary of the study

1. The Al-Hassa water duty model enabled HIDA to define—for the first time—the irrigation water demands of various crops on a daily, monthly and annual basis for 21,000 farms.

2. The application of the irrigation schedule has contributed to savings in water consumption in winter and helped to satisfy the water demands in summer on a fair basis.

3. The study has contributed to improving the technical education level of HIDA engineers. Twelve employees finished a two-year computer course in the United States during 1985-1987.

4. A national water requirement model and irrigation schedule model were developed, using the same methodology for each group of crops in different regions of Saudi Arabia.

Phase III: Development of a water distribution plan for the Al-Hassa Irrigation Project

Client: Al-Hassa Irrigation and Drainage Authority, Al-Hassa, Saudi Arabia.

Budget: SRls. 760,000.

Duration of project: 19 April 1988-19 April 1990.

Summary of the study

1. This study was a major technical challenge to the KFUPM Research Institute research team, and the final product was original and unique.

2. The application of the research findings has been of great help in improving the irrigation management and agricultural production in the Al-Hassa oasis.

3. The study has contributed to improving the technical education level of the HIDA engineers in the use of different installed software on HIDA microcomputers.

4. The programmes developed can be applied, with some modifications, in other irrigation projects in and even outside the Kingdom, and include: the Al Kharj Irrigation Project, the Al Aflaj Irrigation Project, the Qateef Irrigation Project, the Jordan Valley project and the Al-Ghab Irrigation Project.

5. The study resulted in developing recognized expertise in KFUPM/RI in the different fields of irrigation management, which includes: estimation of crop water requirements and irrigation demands, crop irrigation schedule, and irrigation water distribution in complicated irrigation schemes involving large numbers of farms and crops.

Factors for the success of R and D in the irrigation water management system

1. Close linkage between WRDS and the water user (AL-Hassa Irrigation and Drainage Authority). This helped in understanding the technical nature of the problem, in defining the right work scope, tasks, schedule, costs and research team, and in carrying out the planned R and D tasks successfully.

2. The availability of the required funds for R and D with the Al-Hassa Irrigation Authority.

3. The availability of the data required for R and D in terms of quality, quantity and time.

4. The availability of the expertise required for R and D at the WRDS and in KFUPM.

5. Collective expertise and efforts of a multidisciplinary research team at international levels helped to blend technologies to achieve the objectives of R and D. The experience of several researchers from foreign countries was used.

6. The availability of effective and flexible systems (financial, management and quality control of R and D) at the Research Institute helped in using the available resources and funds to achieve the goals of R and D.

General deficiencies

The main deficiency in the above R and D programme is that the application and use of the R and D product have been confined to the Al-Hassa project, owing to lack of effective linkages among irrigation water users at the national and international levels. There is also a lack of effective intra-institutional networking on national and international levels to transfer the findings and knowledge from R and D for implementation in other irrigation schemes on national and international levels.

Example 2: R and D on the possible alternatives for wastewater and brine water treatment and recycling at a large paper manufacturing plant factory in Dammam Industrial City.

Client: Large paper manufacturing company.

Duration: From 31 October 1994 to December 1995.

Summary of the study

1. This R and D resulted in the introduction of a new approach called the "closed water cycle" (CWC) in industrial plants. The raw groundwater and the wastewater are treated by a new and special evaporation technology called the "mechanical vapour recompression" (MVR) process, and the "falling film" (FF) method is applied to convert the brackish raw groundwater and the wastewater into usable water.

2. This R and D resulted in making the plant nearly effluent-free.

3. This approach was implemented successfully. The adoption of this approach resulted in the recycling of more than 90 per cent of the wastewater, and an approximately 85 per cent reduction in groundwater pumping.

4. Large-scale adoption of CWC will help to reduce groundwater pumping, and enhance water conservation and environmental protection in the Kingdom.

Factors for the success of R and D in wastewater treatment and recycling

1. Close linkage between WRDS and the wastewater producer (paper factory). This helped in understanding the technical nature of the problem and in defining the right work scope, tasks, schedule, costs and research team and in carrying out the planned R and D tasks successfully.

2. The availability of the funds required for R and D in the paper factory.

3. The availability of the data required for R and D in terms of quality, quantity and time.

4. The availability of the expertise required for R and D at WRDS and in KFUPM in the related technical fields.

5. Collective expertise and efforts from a multidisciplinary research team at international levels helped in blending technologies to achieve the objectives of the R and D. The experience of another country was used to implement the suggested technology.

6. The availability of effective and flexible systems (financial, management and quality control of R and D) at the Research Institute helped to ensure that the available resources and funds were used to achieve the goals of R and D.

General deficiencies

The main deficiency in the above R and D programme is that the application and the use of the R and D product have been confined to the paper factory owing to a lack of effective knowledge linkages between industrial plants at national and international levels. There is also a lack of effective intra-institutional networking on national and international levels to transfer the findings and knowledge from R and D to other industrial schemes so they can be implemented on national and international levels.

Conclusions

The R and D in water is vital for securing a long-term water supply for the growing demand, especially in the arid countries of the ESCWA region. The success of R and D and its applications to water depends on solving several major problems: the lack of availability of data, lack of effective linkage with water application organizations, lack of collective expertise and efforts on intra-institutional levels nationally and regionally, the duplication of R and D efforts, and the lack of an effective contribution by the private sector. Lessons drawn from the above two R and D case-studies on water resources by WRDS clearly demonstrate the validity of these important factors.

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Assessment and promotion of R and D in the ESCWA member countries: introductory note on selected industries*

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Introduction

Recent changes have helped to create new global realities characterized by:

(a) The consolidation of a new technological and development paradigm, with production processes increasingly becoming science-based and technology-intensive;

(b) The growing importance of trade in a highly interdependent world with expanding globalized production systems, which calls for special efforts by developing countries to compete in the world markets if they want to avoid further marginalization;

(c) A strong trend towards the opening up and deregulation of the economy, and in particular the abandonment by most developing countries of the import-substitution strategies;

(d) The shrinking role of the State, with a reduction in government expenditure and widespread privatization of public services and public enterprises;

(e) A renewed interest in foreign direct investment, now seen as a key source of capital, technology, market access and management know-how;

(f) An increasing concern about the environment, which is now considered a new dimension of development.

The above challenges will have significant consequences for most developed countries. The position of knowledge as a critical factor of production has been strongly reinforced with the acceleration of technological development, the changes in the shape of markets and the comparative advantage of nations, and the deeper integration of the world economy. The technological gap between rich and poor countries, and the poor countries' fear of marginalization, are increasing.

I. NATIONAL INNOVATION SYSTEMS

The world economy of today is based on new and ever increasing knowledge. This is the reason for the increasing importance of science and technology (S and T). This increasing importance of S and T has led to the emergence of knowledge management as a discipline and profession, with unprecedented leadership opportunities. Governments, firms, universities and research laboratories all take part in this process, building up what has been conceptualized as national innovation systems. The action of these key players and the interaction between them determine the impact of S and T activities and, more generally, of innovative strategies for enhancing the well-being of nations. One of the greatest challenges in maximizing this impact is to understand and manage the complex processes that underlie world-class S and T commercialization, including informed education policies, the protection of intellectual property, and the funding of science, technology and innovation.

As knowledge increasingly becomes the key strategic resource of the future, our need to develop a comprehensive understanding of knowledge processes for the creation, transfer and deployment of this unique asset becomes critical. Natural resources and cheap labours are no longer the key to competitiveness. Business and nations acquire a competitive edge through rapid and continuous improvement of products and of the techniques to manufacture and bring them to market more effectively.

II. TECHNOLOGY AND DEVELOPMENT

There is no unanimously accepted definition of technology: an engineer, an economist and a manager will each have a different understanding of the term. However, technology is generally perceived as a system of knowledge, skills, experience and organization that is used to reproduce and utilize goods and services; it can also be defined as new knowledge that has been transformed into products, processes, services and organizational structures.

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Development aims at economic growth and providing a better life for the people. Means and ways may differ, but it is generally accepted that change can only happen through what we call the "Scientific Approach", which designates a clear and effective role for S and T in the development of societies. Thus technology, together with capital investment and skills, creates new businesses, new markets and new jobs. It is the fundamental engine of sustained economic growth and, therefore, of the quality and standard of living of mankind.

The formulation of a technology policy that serves development as well as national goals should be based on two major elements: "R and D for technology" and "Technology for sustainable development". R and D for technology refers to the generation of scientific and technological knowledge to be applied in the solution of well-defined problems in certain areas of production and social welfare. Technology for sustainable development refers to environmentally sound technology, the goal of which is to attain pre-determined socio-economic goals while maintaining a good quality of environment and ensuring equity within the current generation as well as future generations.

In this context, mention should be made of technology assessment. The latter is a tool to make socio-economic decisions while balancing between the choices for now and for the future. Technology assessment is the first step in technology planning which, in turn, is the first step in technology management. Other steps are implementation, monitoring and controlling. In sum, the major purposes of technology assessment are:

(a) Evaluation of appropriateness of technologies for transfer and adaptation;

(b) Selection of technology for development;

(c) Control of inappropriate technology for protection of the environment.

Technology assessment has been undertaken on a large scale by many developed countries. Developing countries have paid little attention to this capability and are often content to follow the conclusions of assessments by developed countries.

The situation with regard to technological forecasting activities is the same as technology assessment; these activities are almost non-existent in the majority of developing countries. Thus, the needs of these countries for technology assessment and forecasting are urgent and pressing.

The interaction of a society with the S and T community is basic to the identification of the real needs of its people and to finding appropriate solution to their problems. Identifying the community of potential research users leads to better structuring of R and D efforts to meet the real needs of the society. Three groups of users can be identified:

(a) Initial users: researchers who identify problems, design research programmes and projects;

(b) Intermediate users: those who adopt the new knowledge, develop it and put it to work;

(c) Final users: those whose lives are affected by the impact of the new knowledge.

The intermediate users are, in turn, divided into three different types according to their R and D needs. The three types are:

(a) Commercial users: an organization that perceives the potential utility of results in meeting its needs and accordingly finances research, if it is cost-effective;

(b) Potential-investor users: enter the picture only after a solution is in sight, respond to economic opportunities identified by research;

(c) Public-domain users: organization and individuals that use knowledge developed deliberately for the public domain. Means of utilization of research results by these users should be understood. Modes of interaction between doers and users should be clearly outlined.

While research results must be of utility to potential users, they can also prove useful when to society in general plans are related to national needs. A system for R and D planning to serve national development must be established.

III. TRENDS IN TECHNOLOGY

The rate of innovation in the world has accelerated dramatically in the past decade, particularly in the new technologies of micro-electronics, new materials, and robotics. This follows scientific advances in solid state physics, genetic engineering, material sciences, computer sciences and other disciplines in which dynamic work is being conducted. There have also been significant improvements in scientific instruments and analytical techniques. From the demand side, innovation has been driven by intense competition for expanding markets in the world, which has stimulated a strong increase in R and D, design and engineering work, education and specialized training.

New technologies often have a generic nature that makes them applicable to different sectors and activities. For instance, information technology is widely used in manufacturing, telecommunications and service activities, and is transforming the workplace and the way people work. The increasing use of automation through numerically controlled machine tools, computer-assisted design and automated banking has sharply diminished the advantages of cheap labour as a factor in competitiveness, and has increased the need for specialized skills in the factory and in administration.

The new production techniques allow more product diversification, permit higher quality, make for faster processing, and signify shorter life cycles of products. In many cases, material and energy inputs are lowered. New materials are increasingly replacing traditional materials. The substitution of synthetic for natural rubber and of synthetic fibres for jute, optical fibres for copper, carbon fibre composites for steel, and ceramics for metal parts, continues.

The organization of production has suffered striking changes with the introduction of practices such as total quality control, just-in-time supply of components, and other approaches, which are being integrated into a new type of production system. What is now called "lean manufacturing" permits substantial savings in most inputs—materials, energy, labour and capital—in comparison with previous mass production methods. Lean manufacturing was developed in Japan and is making inroads in other industrial countries. In addition, the new hard and soft technologies are allowing the rejuvenation of industrial activities which had been increasingly outdated in many countries, such as textiles and steel-making.

An important aspect of the new manufacturing approach is that the efficiency of a firm increasingly depends on the industrial system within which it is embedded. This leads to a very different approach to improving competitiveness, which is no longer solely related to the efforts of an individual firm.

IV. RESEARCH AND DEVELOPMENT INSTITUTIONS

ESCWA member countries, like other developing countries, have built up significant scientific and technological capabilities during the past three decades in universities, research departments, basic and applied research institutions, industrial and agricultural research organizations, and other components of the S and T infrastructure. Research and development (R and D) institutions have been established as prominent actors in the S and T infrastructure.

1. *Objectives and activities*

Similar types of objectives have generally been pursued by most of the R and D institutions in ESCWA member countries. The objectives were: (a) to conduct R and D with future exploitation; (b) to copy, adapt and create technology for industry; (c) to develop processes and products; (d) to assist the production sector in its production problems; (e) to give advice to Government on technology matters; (f) to act as a source of skilled manpower; and (g) to provide consultancies and services.

With the above objectives in mind, the activities of an R and D institution comprise: (a) supporting services; (b) extension services; (c) research and development; (d) training; and (e) free or curiosity-oriented research.

The supporting services are provided at the institution itself, and include: chemical analysis of samples; physical testing of products; provision of technical information; economic evaluations; and, in the case of some institutes, the preparation and issuance of industrial standards, quality control and certification testing.

The extension services provided to industry include troubleshooting and process improvement, process rationalization, industrial engineering, and quality improvement. Such services are provided on the spot and are classified as extension services as long as they do not require appreciable laboratory experimentation or direct backup by institute facilities.

Research and development are usually oriented towards product development, process improvement or development, materials R and D, and application R and D. Here, it is clear that laboratory experimentation is a must. Such laboratory experimentation may range from relatively minor support work and tactical R and D for particular extension activities, to long-range and strategic R and D.

The training of personnel for industry is aimed at either improving the technological level of local industry (through quality control training) or introducing (transferring) new technology.

Free or curiosity-oriented research is carried out with a view to exploring new scientific areas and allowing the institute's scientific personnel to pursue exciting and intellectually rewarding work.

2. *Problems of R and D institutions*

With the exception of a few cases, the impact of R and D institutions in the ESCWA member countries on modernization and development of industry has been limited. At the same time, foreign technology has continued to be introduced in all modern industrial activities. In most cases, the R and D institutions are not properly connected to the potential areas in the industry, and the pursuit of scientific results has become an end in itself, rather than a means to support industrial development. Such shortcomings are causing increasing concern and bring into focus a number of interrelated issues, which may be summarized as follows:

(a) Many of the R and D institutions have tended to put emphasis on topics of their own choice in their R and D activities, and have not had much success in the commercial application of research results. By not focusing closely on industry, they run the risk of becoming largely irrelevant to the development needs of industrial enterprises. This risk is reinforced by their lag in mastering the new technological fields that are becoming increasingly important for industrial enterprises;

(b) The changing technical, economic and policy environment of the 1990s makes life difficult for the traditional R and D institutions geared to import-substitution industrialization. As economies open up, there is a need to compete in globalized markets, and industry requires assistance to enhance its competitiveness. The new milieu would seem to require a different type of institution, more flexible and better able to help industrial firms facing a new set of challenges;

(c) R and D institutions need to update their scientific and technical manpower, their procedures, their management methods and their installations and equipment. This is a must in order to cope with the new technological realities and the resulting requirements of industry. Stated in other words, the introduction of new knowledge and skills through training of human resources, the selective hiring of new personnel, the use of capable and experienced outside consultants in projects, improving information resources, entering into collaborative research projects, and establishing strategic alliances with other institutions at home and abroad have all become crucial;

(d) The R and D institutions are sometimes under pressure to address problems that are new to them. One important issue is environmental protection, which is becoming a growing concern for industries everywhere;

(e) Most R and D institutions face the problem of funding. Government funding is not sufficient, and the demand from industry has seldom grown enough to compensate for this deficit. Funding of strategic R and D is lacking. The result is low income for the staff members of these institutions, and lack of adequate library facilities, instruments and equipment; this leads to serious doubts about the sustainability of these institutions. This is happening at a time when they should play a significant role in the process of competitive restructuring by helping to upgrade the capabilities of production enterprises to compete successfully in world markets;

(f) The R and D institutions have to adopt trends for a future service mix, which seems to be evolving towards the supply of a true technology package and the creation of new ventures. Some new types of services are: consultancies in technology management; technology transfer and production systems; the use by industry of R and D institutions' installations through, for example, the rental of pilot plants; new services in environmental issues; and involvement in the creation of new enterprises.

3. *Relations with industry*

The difficulty of forging good links with industrial firms is perhaps one of the main problems of the R and D institutions in the ESCWA member countries. Several factors account for this. Among these are the following:

(a) Industrial entrepreneurs show little interest in the services of R and D institutions;

(b) Industry has recourse to technology imports to satisfy its needs;

(c) Many potential clients are small and medium-size enterprises, with a low technological level and a lack of understanding, so far, of the possibility of benefiting from the services of an R and D institution;

(d) Many enterprises lack science-minded personnel with whom the R and D institution may conduct a dialogue on technical matters;

(e) Researchers have often shown unhelpful attitudes, being interested more in their own work than in the needs of industry;

(f) R and D institutions have taken a long time to understand that the commercialization of their services requires them to create a unit with specialized skills;

(g) There has been a dearth of national policies and schemes to stimulate demand on the part of industry.

4. *Redefined missions*

In order to cope with local, regional and international changes brought about by the new conditions of the 1990s, R and D institutions in the ESCWA member countries need to reconsider their objectives and activities. The following points may be suggested in this context:

(a) Efforts should be concentrated on a limited set of technological fields related to industrial activities of importance to the country;

(b) There should be a careful identification of clients and their demands, current and future;

(c) Research should be aimed at the concrete needs of industry and other clients; long-term strategic research should be carried out only when funding is available;

(d) Technological services should be provided according to the industry's demands, and the R and D institution should concentrate on those that cannot be supplied by facilities in industry or by small firms offering technical services;

(e) There should be emphasis on supporting the process of technology acquisition, use and diffusion;

(f) New concerns should be introduced, such as automation, quality and the environment, on which assistance may be given to industry;

(g) Strict attention should be given to the generation of income through commercialization of research and services;

(h) There should be a balance between research and services, since too much of a dedication to the latter will drive away the most gifted scientists and lower the scientific standards of the institute;

(i) It is important for an R and D institution to have organizational flexibility and the capability to change according to the requirements of its industry and environment;

(j) Improving the main management functions of planning, programming, budgeting and evaluation in the R and D institutions has become a must. Strategic planning as a means to update institutions periodically should be exercised. An R and D institution should learn about impending changes in its environment, including technology trends, the characteristics of their clients, and the likely evolution of the clients' technology needs; it should identify new markets and areas of work and choose the best research lines. On the basis of such analysis, the R and D institutions can determine their market strategy, service mix, development of critical capabilities and changes in structure and operation systems to allow for the fulfilment of their vision and to ensure a rapid response to the needs of their clients;

(k) R and D institutions should look at the possibility of increasing considerably their links and their cooperative activities with other local scientific and technological institutions, in order to contribute to the formation of a national system for innovation.

V. NATIONAL SYSTEM FOR PRODUCTIVE R AND D MANAGEMENT: A CASE-STUDY

As a society, Egypt has committed itself to socio-economic development and acknowledged the fact that S and T have an effective role in meeting current and future needs. During the past 40 years Egypt invested very sizeable resources and developed a well-trained science community that, with proper administration, can play a major role in the development process. The 1990 records reveal that 66,732 professional research scientists worked in 318 research institutes. One third of them held Ph.D. degrees.

Seventy-five R and D institutions are affiliated to the Ministries of Agriculture and Land Reclamation; Industry and Mineral Wealth; Public Works and Water Resources; Health and Population; Electricity and Energy; Transport and Communication; Housing; Utilities and New Communities; and Culture. Total manpower in these institutions is approximately 16,000 technical staff, out of whom 3,200 are Ph.D. and M. Sc. holders. More than 60 per cent of the S and T manpower are in the universities, affiliated to the Faculties of Science, Engineering, Agriculture, Medicine, Veterinary Medicine, and Pharmacology.

1. *Academy of Scientific Research and Technology*

In 1971, the Academy of Scientific Research and Technology was established as a government body responsible for planning, coordinating, financing, following up, implementing and evaluating S and T activities in Egypt. We consider three major targets to have been achieved by ASRT:

First: To have enhanced the contribution of the S and T community and institutions in the process of national development;

Secondly: To have encouraged the application of modern technology in areas included in the national programme of socio-economic development;

Thirdly: To have enhanced, developed and coordinated international cooperation in the different fields of S and T.

The role of the ASRT as the national organization in supporting research and development in relation to national needs, and in orienting a sizeable base of the scientific and technological community towards problems of development efforts, is recognized and supported by the Government of Egypt. During the past decade, the ASRT established a framework for its activities based on a general policy that considers development of production and services sectors through

S and T as its target. The ASRT established the organizational structure and has developed suitable management systems for R and D programmes.

ASRT developed its first five-year S and T plan for the years 1982-1987, and the second five-year S and T plan for the years 1987-1992, and is currently implementing its third plan for the years 1992-1997. Plans were developed to coincide with and serve the objectives of the national Five-Year Plans of Egypt. There are over 450 projects sponsored and financed by the ASRT and they have mobilized over 15,000 research scientists affiliated to universities and ministries.

The five-year S and T plans act as a vehicle for communication and collaboration of ASRT with national agencies in the production and service sectors and with R and D institutions. Through this, ASRT participates in technology development and technology assessment, particularly in the industrial sector, introducing the concepts of clean technology and stimulating the creation of special agencies for environmental activities in Egypt.

2. *Science and Technology Cooperation Programme*

At the international level, a number of agreements of a bilateral nature have been put into effect. One of the most noteworthy is the Science and Technology Cooperation Programme (STC) by ASRT and USAID (United States Agency for International Development), which was started in 1990 with the following aims:

(a) Effecting attitudinal and institutional changes in the S and T community, so that scientists and technologists could contribute more dynamically to problem-solving through R and D and engineering (E);

(b) Establishing new links between R, D and E providers and users in the production and services sectors.

The STC has defined 10 R, D and E areas for its activities:

(a) Searching for local raw materials as a substitute for imported ones; (b) local production of intermediate chemicals; (c) quality development of principal products; (d) better utilization of secondary products; (e) process development; (f) manufacturing of new products; (g) waste handling and utilization; (h) pollution control; (I) minimizing production losses; and; (j) manufacturing of capital equipment. STC advertised its services among clients from 21 industrial sectors.

The STC was, and still is, unique in Egypt's S and T community in the following ways:

(a) STC responds only to requests for services made by specific end-users from the production and services sectors;

(b) STC requires full participation of its clients, starting from formulation of the problem and identification of its causes, limitations and socio-economic impact. Group experts carefully define deliverables, specifications and performance measures;

(c) STC provides services to the satisfaction of the end-users.

STC has established an organizational structure that guarantees efficient and dynamic operation in dealing with clients. The STC secretariat is headed by the Executive Director and has five offices: technical liaison (TL); R, D and E; MIS (management information systems); communication; and administration and finance. In dealing with R, D and E users and doers, STC management goes through the following steps: (a) problem area definition; (b) preparation of a background study; (c) open dialogue with users; (d) preparation of a statement of work; (e) request for proposals; (f) advertising; (g) contracting; and (h) post-award monitoring.

During the past seven years STC has awarded 70 contracts that involved 54 firms (32 public and 22 private) and 36 R, D and E institutions. Projects were carried out in 17 governorates and involved 1,705 researchers and technicians (34.6 per cent from the user sector and 65.4 per cent from the R, D and E sectors).

A review of completed projects shows beyond any doubt that R, D and E is a good investment. At present, the STC has intellectual property rights for six contracts with local firms that have gained from the professional skills provided by the STC. At the end of 1996, the STC was converted into an institution under the same name and has become one of the most dynamic bodies of the ASRT.

3. *Conclusions*

S and T are of critical importance to Egypt at this point in the country's history. Egypt's population is growing, and the prospects for further gains from traditional sources of production are limited. Therefore, Egypt must develop specific new directions for its economic growth. Some of these directions will demand R and D work before their potential can be realized.

The new directions include new sectors of industrial production, more and different use of arid and semi-arid land, and changes in cropping patterns in favour of high-value crops. Adequate knowledge on which to base policies promoting these changes has to be acquired. The seriousness of this need must be widely recognized.

Box. Lessons learned through the experience of ASRT and STC

The following lessons can be distilled from the experience and achievements of the ASRT:

(1) There must be proper characterization of potential research users. (2) R and D plans have to be related to national plans. (3) Successful R and D starts with a demand/request from a client. (4) There must be full participation of the client in all stages of project development. (5) Researchers should be selected on the basis of their professional skills rather than their academic status or achievements. (6) The statement of the work to be done should define agreed upon deliverables in quantifiable terms and with detailed specifications. (7) Technical elements must be integrated with economic, social and environmental elements. (8) The organizational structure should have a defined mission, effective leadership, qualified and trained staff, an efficient management information system, technical liaison and a communication system. (9) All services should be delivered to the satisfaction of the client.

S and T are also critically important to Egypt with respect to imported technology. Unquestionably, the opening of Egypt to foreign experience, technology and management expertise can have a revitalizing effect on the Egyptian economy. However, without a strong Egyptian S and T community, which is able to absorb and adapt the imported technology to meet Egyptian needs, the results could be much less than anticipated.

The S and T community plays an important role in finding new ways to meet the economic challenges caused by a growing population and limited resources and is also involved in importing technology. In addition, this community has to participate more fully in the modernization process. The S and T community must participate as active and effective contributors to policy analysis and must be developers of technological adaptations and innovations. The S and T community is also responsible for the education of the young people flocking to Egyptian universities.

Research and development must be linked closely to national goals and planning, and research results must be of utility to the community of users and the society at large. Research resources should focus upon critically important national needs or problems, and should not be diverted to parochial objectives. A strategy for S and T should emphasize five major issues:

One: Improve Egyptian policy-making processes related to S and T, particularly those concerned with significant investment decisions;

Two: Strengthen demand from the productive sectors for R and D;

Three: Improve the problem-solving capability of the Egyptian S and T community through better linkages with the user community;

Four: Focus attention on the role of science in society. This includes popularization of science and more interdisciplinary work to help to define the social effects of modernization and the socio-economic implications of various technological alternatives.

Five: Provide recognition of and support for the positive and influential role of the Academy of Scientific Research and Technology, national R and D Institutes and the university community in promoting the application of S and T to development.

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