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SCIENCE AND TECHNOLOGY INDICATORS

BASIC CONCEPTS, DEFINITIONS AND PROSPECTS FOR DEVELOPMENT

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Preface

Statistics on science and technology (S and T) are a prerequisite to the formulation of national science and technology (S and T) policies. They also provide important inputs for the design of policies aimed at modernizing as well as enhancing the competitiveness and productivity of the production and service sectors.

The present study briefly 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. In particular, efforts by UNESCO are analysed and critically assessed.

The main classes of indicators and their attributes are considered in the study. It is noted that currently used S and T indicators are of a general nature, which diminishes their utility in addressing issues relating to the challenges and opportunities that most S and T systems in the developing countries have to confront today. Thus, while extremely useful as bases for historical and international comparative studies, currently used S and T indicators tend to have limited value in detailed policy analyses aimed at capacity-building in specific priority areas.

The final part of the study reviews the underlying bases for additional S and T indicators which may be applied to reduce or eliminate some of the more glaring oversimplifications of "conventional" systems of S and T indicators. Through combining indicators that address more directly the output and quality of S and T activity with those currently in use, a more effective set of integrated indicators may be constructed, thus imparting greater specificity and responsiveness to the exercise of measuring S and T capacity-building.

Throughout the study, emphasis is placed on indicators designed to measure the research and development (R and D) and higher education components of the S and T system. This is primarily due to the fact that these two components constitute the most important means of accelerating endogenous S and T capacity-building. An additional reason for focusing on these two components is the fact that indicators designed to measure their progress have, in many ways, remained relatively unchanged since the 1960s and the 1970's, while tremendous changes have taken place in the dynamics of the R and D enterprise, in methods used for training research manpower, and in S and T planning, as well as the dissemination of S and T information.

The study concludes by considering a set of S and T indicators in the context of S and T policy formulation and sets of quantitative/qualitative and input/output criteria for measuring the performance of higher education and R and D systems at the institutional and the national levels.

A primary objective of the present undertaking is to re-initiate efforts aimed at S and T assessment and to revive interest in an improved set of S and T indicators that are better able to serve activities currently being carried out in the ESCWA member countries. Finally, this study is also intended as a basis for activities planned by ESCWA for the biennium 1998-1999. These activities will include a detailed study and an expert group meeting on science and technology policy for the next century.

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ABBREVIATIONS

ALECSO	Arab League Educational, Cultural and Scientific Organization
ESCWA	Economic and Social Commission for Western Asia
FTE	Full-time equivalent
GDP	Grand domestic product
GERD	Gross domestic research and development
GNP	Grand national product
NGO	Non-governmental organization
NRC	National Research Centre
OECD	Organization for Economic Cooperation and Development
QC	Quality control
R and D	Research and development
ROI	Return-on-investment
ROR	Rate-of-return
ROSTAS	Regional Office for Science and Technology in the Arab States (UNESCO)
S and T	Science and technology
SET	Science, Engineering and Technology
SMEs	Small and medium enterprises
UNESCO	United Nations Educational, Scientific and Cultural Organization

I. THE ISSUE IN PERSPECTIVE

A. INTRODUCTION

With so many problems in sustainable socio-economic development directly dependent upon acquiring endogenous capabilities in science and technology (S and T), monitoring progress in S and T capacity-building acquires greater urgency than ever before. A number of methods have been used in the past to measure societal support for S and T activity. Similarly, a number of techniques have been developed and applied in examining the performance of S and T systems and to evaluate output produced by S and T activity as embodied in new products, processes, publications and patents.

Many of the indicators developed for monitoring S and T activity are applicable to a variety of socio-economic systems in various stages of evolution. Some of the more sophisticated methods for S and T assessment, however, rely on indicators which presuppose relatively developed abilities in the collection and collation of intricate information about the state of, and the nature of activities undertaken by specific components of S and T systems. Some assessment methods are not even relevant in any meaningful manner to S and T systems that may justly be regarded as going through the stages of early development. Such is the case of a number for quantitative S and T indicators that rely on economic parameters, including return-on-investment in R and D and the balance of technology trade.

The methods for measuring support for S and T in a given country or community have tended to stress input and supply considerations as well as comparability across national boundaries. Emphasis has been placed on macro issues, while the particularities of specific situations that arise within certain socio-economic contexts have often been glossed over. It is for this, and a number of other reasons, that the need to review current S and T indicators must be reassessed and avenues for their development mapped out, so that these indicators can better serve the purpose of enhancing S and T capacity in the ESCWA member countries.

B. THE NATIONAL SCIENCE AND TECHNOLOGY SYSTEM

The term "science and technology system" is generally used to describe the body of policies, regulations, institutional and infrastructural arrangements and activities concerned with the creation, acquisition, dissemination, adaptation and further development of scientific and technological knowledge.[1/] Some authors,[2/] have gone as far as to include the application of scientific knowledge and technological innovations among the functions of national S and T systems.[3/] However, the inclusion of "dissemination" of S and T in the above definition implies concern with horizontal technology transfer as well as S and T

[1/] Freeman's description of the (national) system of innovation as the "network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies," bears some resemblance to the above definition [1]. It differs from the description of an S and T system in two important respects. There is, first, the fact that the interests of an S and T system extend beyond technology to encompass scientific research in all its forms and orientations. Secondly, there is the fact that a system of innovation, in this description, deals only with new technologies and excludes a number of activities with which a national S and T system is concerned. An obvious example would be research on the history of science and technology, which performs a valuable cultural function, but may not be included as one of the functions of a national innovation system. A national S and T system is, nevertheless, to be considered an important contribution to a complex and heterogeneous national system of innovation.

[2/] The ALECSO strategy study [2].

[3/] The present study will not adopt the latter position, i.e. it does not regard activities related to the application of S and T knowledge as purely the functions of a national S and T system. It should, however, be recognized that activities aimed at the application of scientific and technological knowledge constitute a common subset of S and T, as well as production and services systems. The strength of forward and feedback links established between elements within this subset and those in the "traditional" set of S and T activities will generally measure the extent to which the national S and T system under consideration has succeeded in addressing issues relevant to socio-economic development.

education, particularly at the tertiary and vocational levels. It also implies concern for spreading S and T awareness at the popular level. Notwithstanding the crucial importance of these components/activities of national S and T systems, the present study focuses on the research and experimental development components of the much wider S and T system referred to in the above definition. Aspects relating to the measurement of the performance of higher education systems will also be briefly considered.

The very use of the term "system" in describing the collection of heterogeneous entities listed above emphasizes the intention to establish an analogy with the notion of an engineering system. The latter is characterized as possessing input, output and operational mechanisms that include both intrinsic processes and more or less complicated linkages to the system's surroundings through both direct and indirect means.

S and T systems cannot be subjected to the rigorous analysis that one might more successfully employ in the physical or engineering sciences. Nevertheless, adopting the notion of a system in the context of evaluating the state of S and T in a particular country will help to elucidate several functional aspects of this system's components, their interactions and their impact on national and regional development. In particular, the notion of an S and T system may be useful at a preliminary level of the analysis, at which point the particularities of the sector or the discipline under consideration need not be considered in great depth. In reviewing the intricacies of certain sectors and disciplines, however, this notion will tend to become less useful. Greater attention will have to be focused on issues that do not bear much resemblance to the workings of an "engineering system", such as creativity; a tradition of research in certain disciplines or lack thereof; and the social implications of research and technological development efforts.

While the notion of the traditional "engineering system" may be useful as a framework for preliminary discussions, more profound considerations might invoke analogies adapted from the notion of "biological systems." For it is only such systems, so far, that may acquire the facility for "intelligent" interaction with their surroundings, as well as effective and purposeful monitoring of their internal workings in order to arrive at optimal growth and effectiveness. While it may not be possible to develop or invoke analogies of this nature in this brief study, a "biological" rather than an "engineering" paradigm will nevertheless provide greater help in the monitoring and assessment of a properly functioning S and T system and, in particular, the workings of its technology acquisition and R and D components. It should be noted that most of the industrialized countries owe their present status in S and T to the fact that the S and T systems they developed possess rudiments of "self-consciousness" and the ability for "effective self-assessment and control", both characteristic of the more intelligent biological, rather than traditional engineering, systems.

II. SCIENCE AND TECHNOLOGY INDICATORS

Interest in the development of S and T indicators stems from the need to monitor and, subsequently, to enhance S and T capabilities. Indicators developed and utilized by world bodies, such as UNESCO and the Organization for Economic Cooperation and Development (OECD), were conceptualized with these purposes in mind.

Box 1 presents some of the basic definitions upon which S and T indicators in current use are based. These definitions derive from UNESCO and OECD sources and conform to the Frascati manual published by OECD. The collection and compilation of data in almost all developed countries is carried out on the basis of the definitions given in box 1. Established S and T indicators based on these definitions are applied in the OECD countries, and in an increasing number of East and Central European as well as South-East Asian countries. Nevertheless, it would be prudent to look at a number of these definitions in a fresh light. Thus, in view of the developments taking place in a number of S and T areas, principally in micro-electronics, new materials and microbiology, it is no longer possible to accept the current definition of basic research, for instance, without some qualifications. Numerous research projects that now seek to acquire "new knowledge of basic phenomena", are directed at an ultimate application which, in some disciplines, may not be as far off in the future as used to be the case. This has led to a new category of R and D activities: "strategic basic, or fundamental, research." Research in this domain is taken to include all scientific activity, often performed at the boundaries of knowledge in a particular field, that is aimed at gaining a better understanding of basic phenomena with the ultimate goal of application in new or improved products and processes. It should be noted that the divisions defined in box 1, are considered outdated by some authors [14]. It is thus considered that the traditional distinction between basic and applied research, between academic and industrial research and also between science and technology is gradually becoming more obsolete. The gap between these areas is being continually bridged by the need to move activities in both science and technology into areas at the forefront of knowledge. The use of the above definitions as bases for the development of S and T indicators must be conducted with this notion of fading demarcation lines in mind. However, it will still be possible to distinguish two broad areas of activity which may still be handled under strictly separate sets of conditions, particularly in the ESCWA member countries. These are activities aimed at penetrating new areas of knowledge, as opposed to those aimed at the development and improvement of products and processes [14].

In the definition of applied research there is often a practical need for distinguishing between acquiring new knowledge for a specific practical purpose and defining methods of applying the results of basic research [3]. It should, also, be noted that the definitions of S and T activities do not include an important function of S and T systems throughout the world: material characterization testing, standardization and quality assurance. It may be argued that these activities should be considered as more related to industrial or productive activities. However, the fact that they increasingly involve S and T personnel, both as researchers and supporting-service providers, and that they do constitute, in themselves, the focus of much innovative activity as well as the locus for the application of "new knowledge of basic phenomena", justifies their inclusion as another subset of joint S and T/production activities. In short, the definitions given in box 1, constitute a reasonable classification of S and T activities. Nevertheless, they should be applied with due regard for the specifics of each situation.

A. S and T indicators in the UNESCO Statistical Yearbook

Historically, national efforts aimed at the implementation of S and T indicators have largely been inspired by UNESCO endeavours. It is only in a small number of countries that more elaborate indicators have been developed, which look in greater detail at the output of national S and T systems and consider in some depth the qualitative issues pertaining to the characteristics of national S and T systems. It is probable that the selected indicators published by UNESCO on an annual basis in its Statistical Yearbook, are the most internationally utilized measures of S and T activity. Their reliance upon standard economic parameters is a great advantage in an international and historical comparative study.

Box 1. Basic definitions in S and T indicators[a/]

(S and T activities)

Research and experimental development

Research and experimental development (R and D) is defined as "creative systematic activity undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications" [3]. This definition of R and D encompasses the following types of activity.

Basic research

Basic research is defined as "experimental or theoretical work carried out for the purpose of acquiring new knowledge of basic phenomena and observed facts without having any previous directive for any specific use. Basic research analyses the characteristics, structures and relations so as to verify hypotheses, theories and laws. The results of basic research are in the main not proposed for commercial use but published in scientific journals or in other ways disseminated to those interested" [4].

Applied research

This is research conducted with the aim "of acquiring new knowledge but, as distinct from basic research, directed towards a specific practical goal or purpose. It is carried out so as to define the possible methods of applying the discoveries of basic research or to define new methods or ways of achieving some specific and previously defined goals. They include the application of available knowledge and its upgrading, which is necessary for solving specific problems" [4].

Experimental development

Experimental development is systematic work which springs from the existing knowledge acquired from research and practical experience and directed towards the production of new materials, products and equipment, for the introduction of new processes, systems and services or for mere improvements of those that already exist.

Scientific and technological innovation:[b/]

Scientific and technological innovation is defined as the "transformation of an idea into a new or improved product for the market, into a new or improved process used in production or in trade, or a new approach in public services" [4].

The term "R and D" implies a notion distinct from that associated with "scientific and technological innovation." On the other hand, R and D activities have to be performed at various points in the innovation process and can even be resorted to following the application of a given innovation.

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a/ Definitions and concepts used by UNESCO in monitoring R and D are based on the "Recommendation concerning the International Standardization of Statistics of Science and Technology" [3].

b/ The basic guidelines and recommendations for collecting or interpreting data on technological innovations are collected in the OSLO Manual published by the OECD in 1992 [4].

Box 1. *(continued)*

Human resources

R and D personnel

Manpower in R and D is defined as including all those employed in actual research and experimental development activity in addition to employees who provide direct support and auxiliary service to R and D activity. This includes managers, planning specialists, information and documentation specialists, as well as technical staff, such as laboratory technicians and workshop machine operators, etc.[c/]

S and T personnel

Personnel employed in S and T activities comprise three categories grouped in accordance with the duties they perform and their initial qualifications.

Scientists and engineers are persons trained, usually up to the tertiary level, in fields of science and engineering, "engaged in professional work on R and D activities", in addition to "administrators and other high-level personnel who direct the execution of R and D activities" [3].

Technicians are persons with "vocational or technical training in any branch of knowledge or technology," normally lasting "at least three years after the first stage of second-level education," who are engaged in R and D activities [3]. Their work is usually conducted under the supervision of scientists and engineers.

Auxiliary personnel are persons "whose work is directly associated with the performance of R and D activities, i.e. clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in the various trades and all other auxiliary personnel. Excludes security, janitorial and maintenance personnel engaged in general house-keeping activities" [3].

Full- and part-time R and D personnel and full-time equivalent

Data concerning manpower resources committed to R and D activity are normally calculated in terms of full-time equivalent (FTE), "especially in the case of scientists and engineers" [3].

Full-time equivalent (FTE): The concept of full-time equivalents is used to "convert figures relating to the number of part-time workers into the equivalent number of full-time workers" [3].

Research organizations

The concept of a research organization is not defined by the Frascati manual. Only "reporting units" and "statistical units" are referred to by the manual. The former are defined as "the source for acquiring" data in accordance with the manual's recommendations [4]. Furthermore, the manual does not provide member States with recommendations regarding reporting units, since they normally tend to be "dependent on the institutional structure" and are generally bound by hierarchical and other considerations dictated by convention and national priorities.

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c/ Work performed by technicians and research assistants generally requires knowledge, skill and experience in specific fields of science and technology, as well as the social sciences and humanities. Technical tasks performed by assistants are usually carried out under the supervision of a researcher. An optimal ratio of researcher to assistant technical staff thus prevails, which may vary from one field to another.

Box 1. *(continued)*

S and T institutions

A statistical unit is generally an "observation unit for which information and statistical data have been collected or an analytical unit which the statisticians create for allocating or for combining" data collected by other statistical units. The latter activity is often carried out with the aim of "acquiring more detailed or more homogeneous data" [4].

R and D efforts are measured in four sectors: business enterprise, higher education, government and private non-profit. In each case, quantitative input indicators would comprise manpower, funding and information resources. Quantitative output indicators, on the other hand, would consider publications and patents as well as measures of citation frequency.

Sectors of performance

"Sectors of performance" are defined by UNESCO as "those areas of the economy in which R and D work is performed" [3]. They are often sectors in which R and D results are also applied. However, the term "sector of performance" distinguishes the activity of carrying out R and D from its financing.

The following sectors of performance are identified by UNESCO: the productive sector, the higher education sector and the general service sector.

R and D in the productive sector: In this sector, R and D activities that are integrated and those that are not integrated with production are distinguished. The productive sector according to the UNESCO terminology, covers "domestic and foreign industrial and trading establishments which produce and distribute goods and services for sale" [3].

The higher education sector: This sector encompasses establishments of tertiary education and includes "research institutes, experimental stations, etc., serving them" [3].

The general service sector: This sector includes "public or government establishments serving the community as a whole" [3].

Financial inputs in R and D

Gross domestic R and D (GERD), encompasses all expenditure on R and D in a given nation during a given period of time. This indicator also covers domestic R and D activities funded from abroad, but excludes national funding of R and D activities performed abroad.

In international comparisons, use is made of indicators which link data on R and D expenditure to principal economic yardsticks, such as gross national product (GNP). An example of such an indicator is the GERD as a percentage of GDP.

R and D expenditure

R and D expenditure is determined "on the basis of intramural current expenditure,[d/] including overheads, and intramural capital expenditure." Total domestic R and D expenditure, according to the UNESCO definition, is "the sum of all intramural expenditures incurred by the national institutions." Total R and D expenditure "refers to all expenditure made ... in institutions and installations established in the national territory, as well as installations physically situated abroad" [3].

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d/ UNESCO definitions further divide current intramural expenditure into labour costs and other current costs.

Box 1. *(continued)*

(S and T funding)

Source of funds

The following sources of funding for domestic expenditure on R and D activities are identified in the UNESCO indicators:

Government funds: include funds provided by central or State government, as well as local authority;

Productive enterprise funds and special funds: comprise financing for R and D provided by productive sector institutions;

Foreign funds: relate to financing received from donor governments or organizations based "abroad for national R and D activities" [3].

Other funds: includes all other sources of financing that do not fall under any of the above headings. Examples of such funding sources might include contributions from non-governmental organizations.

These "selected indicators" are presented under two separate headings in box 2, namely, "scientific and technical manpower" and "expenditure on research and experimental development". Data published in the UNESCO Yearbook constitute the most comprehensive set of information available on science and technology manpower and R and D expenditure worldwide. In the UNESCO data on S and T indicators, focus is maintained on the input components of R and D activity with emphasis on manpower and expenditure. However, in another section of the Yearbook, which deals with higher education systems graduates, "output" and areas of specialization are highlighted by the statistics.

Box 2. Selected science and technology indicators

SCIENTIFIC AND TECHNICAL MANPOWER

Number of scientists and technicians engaged in research and experimental development;

Number of scientists and technicians engaged in research and experimental development by their field of study;

Total number of personnel engaged in research and experimental development by sector of performance and by category of personnel.

EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT

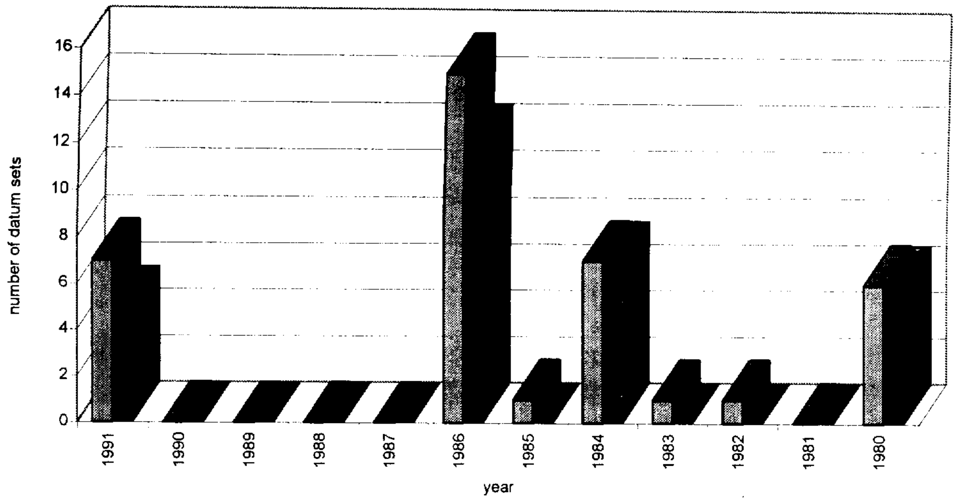
Total expenditure for research and experimental development by type of expenditure;

Total expenditure for the performance of research and experimental development by source of funds;

Total and current expenditure for research and experimental development by sector of performance.

Two of the main shortcomings of the data published by UNESCO on S and T, in as far as the ESCWA member countries are concerned, are: limited coverage and outdated information. Thus, in the 1995 and 1996 Yearbooks, data on only 5 out of the 13 ESCWA members countries are available.[1/] Furthermore, data published in 1996 within the section on science and technology concerning the ESCWA member countries reveal no change from the data published in 1995. This is most probably a reflection of the inadequacy of national S and T monitoring and assessment bodies in the member countries that generally report to UNESCO on national S and T developments. It may also be due to the tendency in some quarters to regard details of R and D expenditure and S and T manpower as privileged information.

Figure I. Numbers and reporting dates of datum sets concerning the ESCWA member countries in the 1996 UNESCO Yearbook



The annexed tables in this study present data concerning the ESCWA member countries. The data are drawn from the section dealing with science and technology of the 1995 UNESCO Yearbook. Data for the ESCWA member countries in the 1996 Yearbook correspond exactly to the data published in the 1995 issue of the Yearbook, indicating no changes reported in any of the parameters relating to R and D manpower or expenditure. Figure I provides a graphic presentation of the dates of the latest available entries concerning these countries [5].[2/]

B. THE ROSTAS REPORTS ON THE HIGHER EDUCATION AND R AND D SYSTEMS IN THE ARAB COUNTRIES

A report prepared for the UNESCO Office in Cairo, the Regional Office for Science and Technology in the Arab States (ROSTAS), addresses, in two separate volumes, "Higher Education Systems" and "R and D Systems" in the Arab States [6]. In addition to the indicators normally used in describing higher education and R and D systems, the ROSTAS report addresses the quantitative aspects listed in box 3. Published in 1995, this report must be considered a significant improvement on previous attempts aimed at compiling S and T indicators. This is particularly apparent in the depth of treatment of sub-fields, or areas, within the major fields of S and T application and in the treatment of resources for existing R and D systems in the Arab countries. It is also evident in the level of detail adopted in the presentation of data on higher education

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[1/] Data on S and T manpower and R and D expenditure were Egypt for Jordan, Kuwait, Lebanon and Qatar, whose combined population represents more than 50 per cent of the total population of all ESCWA members.

[2/] Datum sets included in this figure relate to the indicators listed in the annexed tables in this study.

Box 3. Quantitative attributes of higher education and R and D systems used in recent ROSTAS studies

HIGHER EDUCATION SYSTEM

Number of universities and faculties and their distribution by: period of establishment, categories of student size, country and major groups of specialization;

Number of departments of basic science and engineering and their distribution by discipline and country;[a]

Number of departments offering higher university degrees, by fields and countries;

Expenditure on higher education as a ratio of GDP;

Student enrolment by level of higher education, field of study and by country, both within students' home States as well as abroad;

Total staff members at universities by level of higher education, field of teaching duties and by country.

RESEARCH AND DEVELOPMENT SYSTEMS

Number of R and D institutional units and their distribution by subject area of research;

Modality (type) and number of R and D institutional units and their distribution;

R and D expenditure in millions of United States dollars and its percentage share of GDP as well as researcher share of R and D expenditure;

FTE researchers in autonomous and ministry-governed institutes and universities in all R and D fields and their distribution by degree held;

Number of B.Sc and other support staff and their distribution by place of work (autonomous and ministry governed institutions and universities);

Number of FTE research staff in autonomous and ministry-governed R and D institutions and universities and their distribution by major R and D area and country;

Summary of FTE research staff in the Arab States and their distribution by 28 areas of R and D activities (grouped in six categories);

Some indicators of agricultural R and D across countries;

FTE research staff and their distribution across countries and by area of research in: Agriculture and Allied Resources; Health, Nutrition, Biotechnology and Environment; Industry; Engineering; Basic Science and others; Energy including Petroleum and Petrochemicals; Humanities and Social Sciences.

Source: *R&D Systems in the Arab States: Development of S&T Indicators and The Higher Education System in the Arab States: Development of S&T Indicators*, report prepared for UNESCO by Subhi Qasem (UNESCO Cairo Office, 1995).

Notes: FTE = full time equivalent.

a/ The list of "basic" science departments includes some applied sciences, such as Industrial chemistry, materials science, laboratory technology and environment.

systems in the countries under consideration and observed trends therein. The inclusion of descriptive material on the nature and duration of higher educational courses, as well as R and D programmes also tends to provide sound bases for further analysis. The fact that the report is based on somewhat recent, 1990-1993 data must also be considered a positive development in comparison with the above-mentioned UNESCO Data.

Neither a quantitative, nor a qualitative assessment of R and D output is attempted in the ROSTAS study. Thus, apart from indicating and grading areas of R and D expenditure in the countries under consideration, the study does not provide much information on R and D output in terms of its value and relevance to sustainable development priorities in the region, nor an research reports, attributions regarding citation and authorship, and co-authorship with other researchers in and outside the region. This situation is also a direct result of the dearth of information on R and D output at the national level which, in turn, relates to inadequate S and T monitoring and assessment bodies.

S and T indicators used by ROSTAS bear considerable similarities to those used in the UNESCO Yearbook and essentially conform to the list of definitions given in box 1. However, a number of factors render the sets of data produced by UNESCO and ROSTAS incompatible. The UNESCO indicators possess the important advantage of having been in use for a considerable period of time. This has rendered them familiar in terms of structure and intent. However, at the conceptual level, the UNESCO system of S and T indicators is firmly rooted in developments that took place in the 1970s and early 1980s.[3/] This may be due to the fact that S and T institutions are still lagging in this area. Nevertheless, the normative value of collecting and publishing data with reference to a particular set of indicators should be clearly recognized.

The numerous additions made by the ROSTAS study are certainly worth retaining and even expanding upon. This is an issue that is addressed by this study, with emphasis on the need to include further output and qualitative performance indicators. The following paragraphs will therefore briefly describe some of the more important categories of indicators in preparation for more critical assessment of R and D and higher education indicators, with emphasis on the former.

[3/] And by association, though to a lesser extent, the ROSTAS system of indicators.

III. CATEGORIES OF S AND T INDICATORS

Among classes of indicators that deal with the performance of components of S and T systems, those concerned with higher education are of particular importance for the future status of both R and D, as well as higher education systems, and ultimately the process of S and T capacity-building itself. The higher education system in a given country is the major, if not the sole, source of S and T manpower. It is also often a valuable partner in R and D exercises. Its evaluation should hence be awarded priority position in the study of S and T indicators. Section A below briefly reviews some indicators that have been used to assess performance in higher education. This will be followed in section B by a similar review of R and D indicators. Subsection 1 in section B covers indicators used to evaluate R and D at the institutional level, and subsections 2 and 3 present a critical assessment of some of the more pertinent aspects of S and T indicators.

A. Higher education indicators

In the case of indicators for the higher educational and vocational training components of S and T systems, the use of input indicators (mainly financial support) as well as output indicators (numbers of graduates) has been commonplace.

Figures for spending on higher education, the numbers of students enrolled in the various stages of learning, as well as the number of professorial and assistance staff, may be considered a basis for a set of primary or basic input indicators. As noted in box 3, which includes lists of S and T indicators used by ROSTAS, these encompass indicators that consider spending on higher education, as a whole, in relation to gross domestic product (GDP). Figures on enrolment and graduates can also lead to similar sets of primary indicators. From these indicators, a host of "secondary" indicators are derived which may relate to annual spending per university or vocational college student. The ratio of students to professorial and assistant staff, is another example of indicators which may be derived from figures on enrolment and teaching staff.

As noted above, output indicators in higher education and vocational training often refer to numbers of graduates. The quality and effectiveness of higher educational systems are sometimes assessed on the basis of student-to-staff ratios, level of success in completion of course work (alternatively drop-out and failure rates), the availability of advanced equipment and modern means of instruction, with both numerical and qualitative measures used. The speed with which graduates obtain employment is a measure which, although indicative of the quality of higher education and training, is also tied to more general economic conditions.

B. R and D indicators

As noted above, this study will concern itself, principally, with indicators that are directly linked to R and D and higher education, with emphasis on the former. R and D indicators may be grouped within two main categories on the basis of their innate nature, i.e. quantitative or qualitative, or the facets of the R and D process they aim to address, i.e., input and output processes (see box 4). Both major types of indicators may be divided into sub-categories that add specificity to the process of R and D assessment, on the basis of the component(s) of the S and T they address, as well as the specific purposes of a particular evaluation exercise. In particular, qualitative indicators may cover aspects relating to the efficiency of the R and D system in question, its effectiveness in addressing problems of sustainable development, as well as its linkages to other sectors in the overall socio-economic setting. Furthermore, both input and output indicators may be dealt with from quantitative, as well as qualitative viewpoints. In certain cases, quantitative measures of R and D output may provide quasi-qualitative measures concerning the orientation of the R and D system. An example of this is provided by counts of patents awarded in a given area application. The list of R and D activity types and attributes presented in box 4 may also be used to generate a variety of useful indicators to ensure a closer view of sectoral, institutional and disciplinary dynamics and interactions. All categories of indicators have been used in one situation or another more or less successfully, depending on the amount of information available. The prevailing tendency in R and D assessment has been to emphasize quantitative input indicators. The difficulty of assessing R and D output has tended to accentuate (or popularize) indicators such as expenditure on R and D, the number of R and D personnel, and the number of R and D projects in a particular area. Out of the simpler more basic indicators, such as annual expenditure on R and D relative to GDP, the number of projects in a given area and the number of researchers per 100,000 inhabitants, it is possible to determine a number of "secondary" indicators. These may include the number of researchers per project in a given area and the annual expenditure per researcher and per project.

R and D output indicators, as embodied in publications, patents and trade secrets, are commonly used in the industrialized countries. From such output indicators, it is possible to derive research intensity indicators, including publications per capita and per institution, discipline and country.

Research activity in most of the ESCWA member countries is still dominated by government and university institutions. However, there are indications of increasing contributions by business as well as non-governmental organizations (NGOs) in certain areas. Contributions by the latter organizations may be different in both content and orientation from those of government research centres and universities. The importance of their contributions in answering certain S and T needs has been manifested in a number of industrial and newly industrializing countries. It is therefore important that indicators developed for the assessment of S and T activity address the institutional origins of output. This is generally taken care of in statistics published on the subject through indications of the source of funding for R and D (see annex table B.3).

It should be noted that R and D assessment within institutional entities often requires, and can support, the utilization of more sophisticated or at least more detailed indicators. The following is a brief review of issues relating to R and D assessment at the institutional, or micro-level.

1. *Institutional R and D indicators*

R and D performance measurement at the institutional level has attracted significant attention in the past.[1/] It is the unique aspects in the situation, mission and type of R and D carried out and the availability of data that largely dictate the choice of indicators for the assessment of an institution's R and D performance. Nevertheless, certain indicators are generally found to be of common interest to a wide spectrum of institutional types and missions. With regard to the input and quantitative aspects, indicators include the number of scientists employed in R and D departments, expenditure per project and per researcher, overall investment in the purchase of new equipment and in building new facilities, and time allocated from initiation of a project till its completion. On the output side, considerable variations have been noted among different types of institutions.

Several institutions in the industrialized countries have exhibited a keen interest in the financial criteria for evaluating R and D performance. Thus, metrics related to financial aspects of R and D output are reported as being particularly popular in the United States of America at the firm level, while little interest

[1/] Werner and Souder report that up to 90 articles, 20 books and two research reports were published on the subject during the last four decades [7].

is shown in such indicators in countries such as Germany, for example.[2/] A recent survey covering a sizeable sample of United States firms has revealed that "various versions of rate-of-return (ROR) or return-on-investment (ROI) indicators" are applied routinely to measure the performance of R and D teams [8]. Another indicator that has been used, also by commercial enterprises, is the break-even index. The use of this index to measure R and D success is possible in situations where a high rate of product or innovative process output pertains, as it measures the time needed to recover initial expenditure on product or process R and D. However, the prevailing view is that integrated metrics, combining both quantitative and qualitative indicators, are the most effective [7].

Box 4. Attributes of R and D systems and related indicators

COMMONLY ADDRESSED ATTRIBUTES OF R AND D SYSTEMS

Quality
Productivity
Degree of internal and external networking
Extent and strength of links to production/services sectors
Responsiveness to national priorities
Disciplinary structure
Sectoral orientation
Institutional affiliation[a/]
Principal source of drive[b/]

A CLASSIFICATION OF R AND D INDICATOR TYPES

Input: Dealing with resources, mainly human and financial, but also with information resources.

Output: Including new or reformulated knowledge as in embodied products, processes, patents and publications.

Quantitative: Addressing input resources: number of researchers, funding support, as well as output including publications, patents, as well as financial indicators such as return-on-investment (ROI) and break-even index.

Qualitative: Dealing with input and output quality, originality, utility, conformity with original plans, sound utilization of resources, the quality of linkages to production and services sectors, as well as R and D communities within the country, the region and abroad.

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a/ Intra-institutional, inter-institutional, public, private and non-governmental institution types.

b/ The dynamics of R and D may be quite complex. Two extreme situations might be a system that is supply driven, that is, one whose activities are initiated and prompted by availability of resources and apparent possibilities for their proper utilization and one that is demand driven, i.e. one whose activities are requested by end-user(s), hence, oriented towards particular clients and environments. Many more examples closer to the former than the latter extreme may be found in the ESCWA member countries.

Public sector R and D institutions, in general, are not expected and do not appear to be concerned with financial output indicators. In some public sector R and D institutions in the ESCWA member countries,

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2/ Variations in preferences for particular sets of financial indicators, exhibited by certain countries, institutions and firms, have been documented [8].

there is a tendency to evaluate R and D outcome in terms of expected savings made through improved products and processes. One common shortcoming of this approach is the time lag involved in the actual application of R and D results. Delays in the transformation of R and D results into products and processes can mean that the expected initial positive results may not be forthcoming because of certain emerging factors, about which those who made the initial positive estimate may have been ignorant.[3/] Several attempts have nevertheless been made in some of these institutions,[4/] in which serious efforts were made to grade R and D output on the basis of complex criteria, mostly relating to conformity with planning parameters and initial expenditure, manpower and time-to-delivery estimates. One of the major weaknesses of these methods was found to be the absence of indicators that measure the quality of the ultimate end-product of R and D activity for a variety of reasons. Prime among these has been the absence of reliable feedback from end-users, on the one hand, as well as the lack of alternative solutions, on the otherhand.

Considerations related to R and D output have received little attention. The output considerations, output-related indicators concerned will therefore be reviewed in detail in the following paragraphs with reference, wherever possible, to their application in the ESCWA member countries.

2. *Quantitative measures of R and D output*

New knowledge embodied in published scientific discoveries and technological innovations is a principal output of S and T systems. Publicly available sources of information documenting S and T activity include published research reports and patents. Both sources are employed in providing a fairly reliable overall view of S and T activity with possibilities for international comparisons. The tendency has so far been to utilize the numerous research reports and patents with only limited concern for their quality and possible impact on the field of application.

Thus, a measure of the output of a given research system may be made on the basis of the number of research reports in scientific and technical journals. Since levels of substantive and editorial scrutiny employed by various journals tend to vary enormously from one journal to another, it has been the practice to consider only publications that are made in major refereed journals of international and specialized status. Research articles in such journals may provide information on the productivity, the impact, and the orientations of the research base. Furthermore, quantitative analyses of this nature may be applied to address institutional, and even individual, as well as national S and T profiles.

"Knowledge" in its various manifestations, as created by R and D effort, is more difficult to measure. Criteria measuring the originality and the utility of new knowledge should also be used in attempts to gauge the importance of a recent publication that embodies a scientific discovery or a technological innovation. These criteria, as well as others that spring from them, present serious problems in the assessment of R and D publications. The novelty or originality of knowledge embodied in a recent scientific discovery or technological innovation must be determined on the basis of exhaustive surveys of the literature, which, no matter how thoroughly conducted, may still fail to determine whether a given scientific publication embodies a genuine discovery or is simply a restatement or reinterpretation of an earlier discovery made within the same or an adjacent area.[5/] In additional, the utility of a scientific discovery of a technological innovation may depend to a large extent on prevailing economic and social conditions.

[3/] In addition, estimates of savings made because of the development work in question are often based on incomplete and inexpert analysis.

[4/] Private communication.

[5/] Both restatements and transpositions or interpretations of scientific facts may sometimes be of immense value, nevertheless.

3. *Analysis of research publications*

Given the volume of published R and D outputs and the difficulties involved in assessing their utility on the basis of applicability criteria, there has been a tendency to resort to an indirect measure of the importance of R and D, namely relying on the frequency with which a particular publication is cited in subsequent publications.

Research reporting activities have been increasing worldwide. Literally, several million research articles are published each year. The number of publications involving authors and institutions from different countries has also increased. Analysis of publication trends across disciplines reveals downward trends in some disciplines. The fact that it is often in applied science and engineering research areas[6/] that such downward trends are observed supports the notion that restrictions on publication, aimed at protecting commercially valuable R and D results, may be at work.

Comprehensive bibliographic databases have been constructed to document research articles in refereed international journals.[7/] Such databases include information on refereed research reporting throughout the world. The share of world publication outputs in the sciences and engineering disciplines (incorporating the natural sciences, mathematics and computer science, engineering, medical science and agricultural sciences) may be readily determined from surveys based on such databases. The share of a given nation in world publications is generally regarded as a useful indicator of the abilities of its researchers, as well as a measure of future potential for training and further technical development. This indicator is furthermore useful in drawing the profile of the S and T system on the basis of research contributions. From data on the share in world publications, it is possible to determine how broad the S and T system in question is in disciplinary terms.

While the share of world publication outputs is essentially a quantitative indicator, the fact that it derives from a large body of refereed material additionally confirms it as an indicator of research quality. It should, nevertheless, be possible to supplement data collected on the basis of this indicator with qualitative data concerning the topical and sectorial orientations of the published research output.

Attention in the analysis of research publications in the past focused on material published in refereed international journals. This is due primarily to the understandable need to guarantee a certain level of quality in the sample being considered.[8/] Looking at local, but refereed, journals has its advantages. First, it can reveal information about the make-up and orientation of a sizeable proportion of active local researchers. Secondly, it will provide a view of the extent to which local S and T communities are responding to S and T and overall development needs. Thirdly, since an increasing number of foreign authors are using local refereed journals as a medium of research reporting, often through co-authored articles, looking at these publications will provide a picture of cooperative research patterns involving partners from abroad.

[6/] The most significant downward trend in countries such as the Netherlands, for example, has occurred in the engineering sciences.

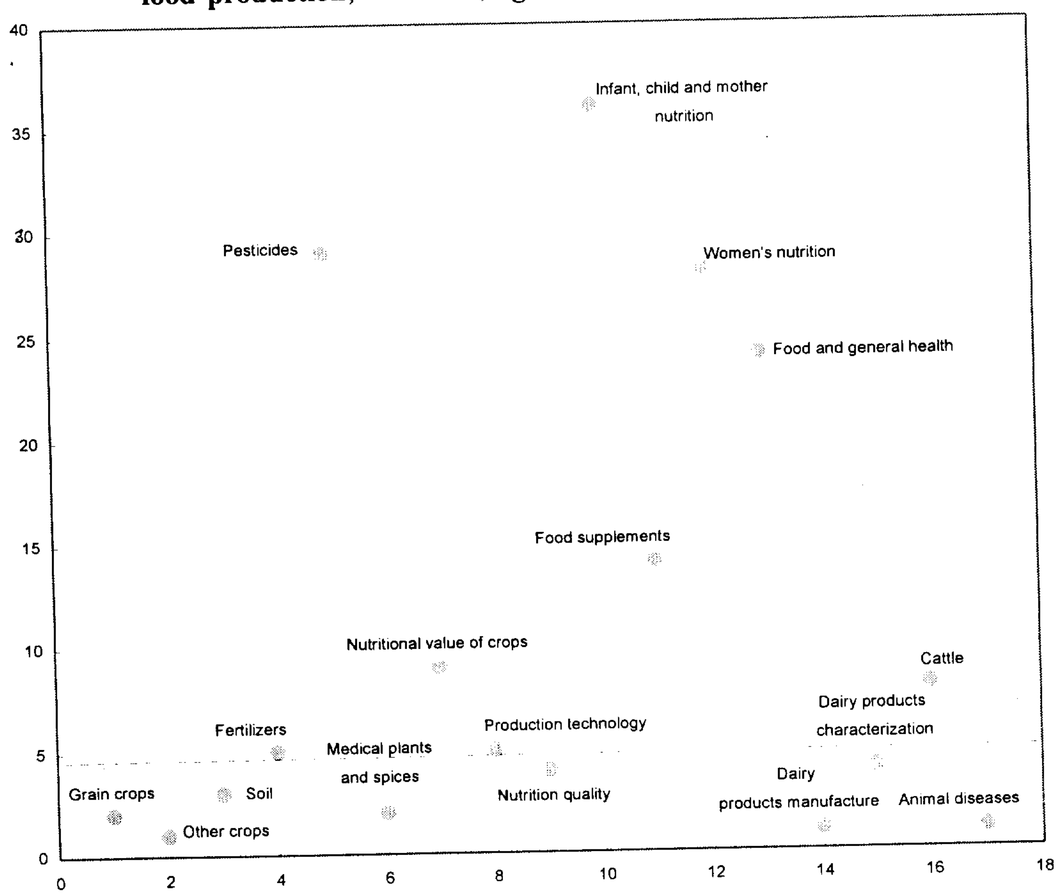
[7/] The principal database, which is being continuously updated and covers monthly and other periodical reports published, is that compiled by the Institute for Science Information (ISI) in Pittsburgh, Pennsylvania in the United States. This database covers a large set of specialized and multidisciplinary journals in science and engineering. Conditions for extending ISI coverage to a particular journal include refereeing as well as the availability of an English language abstract. In general, the ISI database constitutes a satisfactory representation of international mainstream research.

[8/] Publication in international journals is also important for granting local researchers visibility, which is crucial for future cooperation with other groups in the international S and T community.

In this context, it is interesting to review briefly, as an example, the results of an analysis of publications by researchers from the National Research Centre (NRC) in Egypt, which appeared in international and local journals during the period 1980-1989. This analysis revealed areas where exceptionally high percentages of publications appeared in international journals. This, indicates that the research may be destined for greater possibilities of interaction with the international scientific community and in that the quality of research reporting may have surpassed a certain level. Figure II, presents the results of this analysis in relation to the research reporting that took place during the above-mentioned period within the cluster of research reports on food, the food industry, nutrition, agriculture and related areas [9].

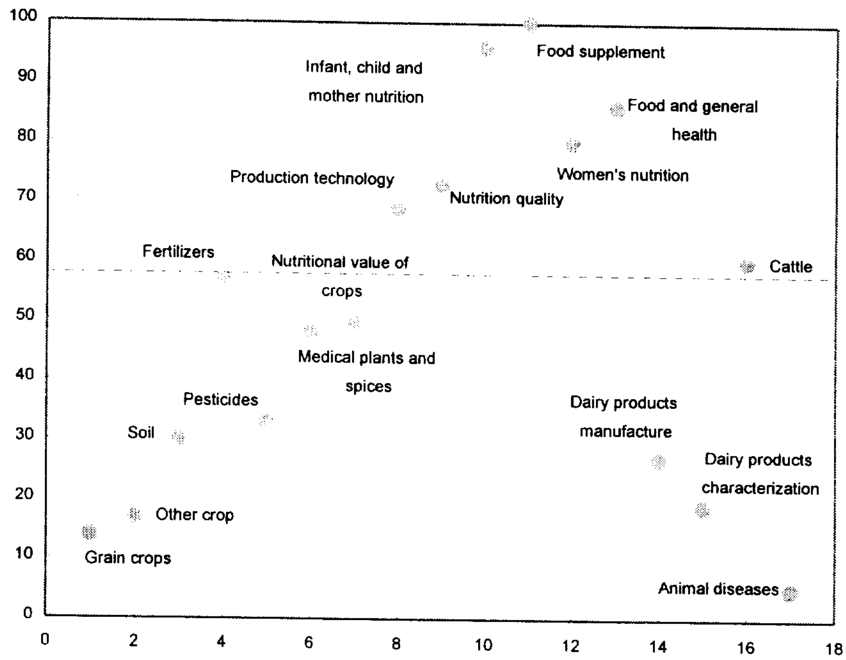
The analysis of co-authorship patterns may be carried a little further. This, however, requires that some simplifying assumptions be made. In the absence of concrete evidence or empirical studies, these assumptions must rely upon experience and general observations. The assumptions concern, principally, the significance of co-authorship patterns with regard to R and D productivity, and the quality of the output of R and D systems. They also relate to the quality of information contained in co-authorship patterns concerning the existence and strength of linkages with production and services sectors as well as the existence of cooperation and coordination arrangements with local and international R and D communities. On the basis of such assumptions, constructions such as figure II may be set up to characterize a given R and D system through observed authorship practices.

Figure II. Percentages of foreign author's participation in research on food, food production, nutrition, agriculture and related areas



Another area that is also of interest in relation to the analysis of R and D publications is that of authorship of research publications in cooperation with researchers from other countries. This is a revealing indicator, not necessarily of output quality alone, but also of exposure to members of the international research community. Figure III provides an example derived from the same data set, regarding publications made by NRC researchers in Egypt during the years 1980-1989, in both local and foreign publications, which shows a distribution of co-authorship involving participation with scientists and technologists from other parts of the world [9].

Figure III. Percentages of publications in foreign journals on food, the food industry, nutrition, agriculture and related areas



4. *Citations of S and T publications*

One way of measuring the impact of a particular S and T contribution following its publication is to analyse the frequency with which the contribution is cited in the refereed literature. It is the availability of computerized databases that ensure ready access to bibliographic material for a given article that make it possible to conduct such analyses. This type of analysis is gaining increasing popularity as a tool for the comparative assessment of researchers, research institutions, and university departments and firms engaged in R and D activity. Although this indicator is a quantative one, it is probably the nearest approach so far to a qualitative measure of research output. The use of citation indexes can provide insight into both quantity (the number of times a publication is cited) and quality of a publication.

Figure IV. Relating co-authorship patterns in relation to R and D attributes[a/]

R and D attributes	Co-authorship involving authors from				
	The same institution		Other national institutions	Foreign institutions	End-user sectors
	Other disciplines	Same discipline			
Productivity					
Quality[b/]					
Links with service and production sectors					
Cooperation and coordination					

a/ No direct causative link is implied by the degree of correlation between attributes in the first column and the indicators in the first row of the table.

b/ Including, originally, thoroughness and depth of analytical aspects, and—at the institutional level—time required for delivery of results, and efficiency in resource use.

Clearly, if a publication is not relevant to the preoccupations of the scientific and engineering communities, it will not be frequently quoted. Similarly, a publication that lacks originality will be by-passed in favour of the original sources. Hence, the necessity, in the ESCWA member countries, for encouraging publications in local as well as foreign journals, while at the same time striving to reform and improve refereeing practices in the former.[9/] It should be noted that the level of citation of S and T publications has been shown to be of some value in the prediction of future S and T performance [7].

5. Patenting activity

Firms, and other institutions engaged in innovative activity apply for patents to secure proprietary rights for the use of related innovations. The patent output generated by a national S and T system generally provides an overall indicator of its technological standing and may be utilized for an assessment of technological specialization *vis-à-vis* other nations.

The extent of technological activity resulting in usable output, product and process designs and information relevant to the production and the services sectors is represented, in large measure, by patenting activity. Thus, the number of patents granted in a given sector to a particular institution, or to researchers in a given discipline, generally acts as an indicator of institutional, disciplinary and individual contributions to innovation in the sector under consideration. The number of patents awarded for applications in a given area, such as microchip design or fermentation processes based on biotechnology, indicates the potential intensity of actual innovation within that area. Furthermore, a positive correlation has been found between R and D expenditure by firms and the number of patents granted on the basis of innovations they produce [7].

In general, assessment of patenting activity in order to gauge the innovative value of a patent, as well as the potential benefits accruing as a result of its application, should concentrate on internationally registered patents. Patent records provided by well-established patent offices generally allow a thorough analysis of

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9/ This, naturally, should never be interpreted as a call for an isolationist approach in research reporting. It is rather a call for enhancing interest in local S and T publishing, as well as enhancing the level of outputs that appear in such publications. This could, ultimately, respond to the need for specialized journals that target S and T issues relevant to the countries of the region and might, if appropriate refereeing/editorial policies are implemented, lead to such specialized journals acquiring international status in their own right.

country and even institutional specializations across technological areas defined by international patent classification codes.

The share of a particular nation in internationally registered patents, often expressed as patents per researcher, is greatly influenced by R and D intensity. Thus the position of Switzerland at the top of the patents/researcher league is explained by the concentration of the highly R and D-intensive pharmaceutical industries in that country. Analyses of patterns of patent authorship are also useful in monitoring the influence of industrial research activity, and in particular R and D activity by multinationals.[10/] University patenting, on the other hand, may be used as a direct measure of potential contributions by academic R and D activities to technological innovation.

Table 1 presents electronically published data on patents originating from a number of ESCWA member countries and registered in the United States during the period 1992-1996. These figures show that Saudi Arabia consistently registered the largest number of patents throughout that period. However, no information is available on the patent titles or areas of application.

The small number of patents registered by operators in the ESCWA member countries is, nevertheless, noteworthy. The total number of patents registered annually by all ESCWA member countries is contrasted with the corresponding number for Israel, which ranges between 350 and 500 per annum.

It should also be noted that the number of patents registered locally, as well as the number of applications for patent registrations, is small. Thus, the total number of patents registered by the patenting authority in Saudi Arabia since its establishment amounts to five patents only [18]. Another indication of the small number of patents produced by researchers in the ESCWA member countries is provided by the fact that researchers at the National Research Centre produced only four patents throughout the period 1980-1989 [9].

TABLE 1. NUMBER OF REGISTERED PATENTS IN EIGHT ESCWA MEMBER COUNTRIES FOR THE PERIOD 1992-1996

	Registered patents					
Country	1992	1993	1994	1995	1996	Total
Egypt	1	1	4	3	3	12
Jordan	1	-	-	-	1	2
Kuwait	1	2	1	1	2	7
Lebanon	1	1	1	1	-	4
Oman	-	1	-	-	-	1
Saudi Arabia	8	4	11	10	12	45
Syrian Arab Republic	2	-	-	-	-	2
United Arab Emirates	1	1	1	1	1	5
Total	15	10	18	16	19	78

Source: Electronic publication, US Patent Office.

[10/] Thus, the large Netherlands multinational enterprises are the main reason why more than one third of patents granted to Netherlands firms cite co-inventors based in another country. The same phenomenon occurs in Switzerland (many multinationals) and Ireland (many foreign firms).

In summary, the quantitative analysis of research reporting and patenting activity produces numerical data that enable a quasi-qualitative characterization of a national- or an institutional-research base. This characterization may be obtained by drawing a map, on the basis of the above-mentioned analysis. This map could expose the range of topics and research areas covered by the research community, the relative strengths in these areas, and the proportion of research outputs co-authored with researchers from other organizations/nations. More difficult indicators that express the degree of multidisciplinarity would have to look at the number of publications co-authored by researchers from different disciplines.

Bibliographic records of research publications in databases dedicated to reviewing science and technology reports include the titles of publications and the names of co-authors as well as institutional addresses. This allows for a useful assessment of S and T productivity at the national, sectorial and disciplinary levels, and the "orientedness" as well as the extent of cooperative R and D activity. Since publications are compiled in these databases on the basis of the area of specialization of the journal concerned, it is also possible to map out institutional areas of interest as well as institutional productivity in a particular area of research activity.

IV. S AND T DEMAND INDICATORS

Demand for local or exogenous S and T inputs may involve consultancies and technical services as well as R and D. Both quantitative and qualitative aspects of this demand may be gauged by reviewing related contractual and other expenditure in such areas and analysing its orientation and distribution across countries and regions.

The recent history of demand for consultancy services was the subject of a survey[1/] carried out by the ESCWA secretariat on the basis of published information about contracts concluded between mainly public sector organizations in the ESCWA member countries and a variety of consulting organizations during a four-year period, 1992-1995. Tables 2 and 3 provide, by way of example, a summary of the results of this survey. It should be noted that these tables can represent only a subset of actual demand. Their usefulness is confined to indicating the directions and the order of magnitude of this demand. The tables nevertheless reveal important information regarding the order of magnitude as well as the sectoral origins of demand for consultancy services. The collection and analysis of information such as that presented in the tables can provide useful indicators for formulating policies as well as defining areas of priority when setting up S and T consultancies and related R and D, as well as technical support services. Collection and analysis of such data should thus constitute as important the work of specialized national and sectoral bodies in the ESCWA member countries. A less direct, but no less useful, picture of "demand" for S and T is provided by contracts concluded for the acquisition of specific facilities, related to production, service or natural resource utilization. Thus, tables 4 and 5 provide an overview of this demand as represented by information published on contracts reported as concluded by ESCWA member countries for the purchase of facilities in agriculture, fisheries, transport, industry, infrastructure, services and tourism. It should be borne in mind that the figures quoted in these tables do not reflect the full extent of demand in the sectors indicated. Nor is it possible to state that this demand could, in any way, have been satiated (or met) on the basis of local technology inputs. Nevertheless, by virtue of their considerable value, the contracts reported as concluded in the sectors indicated in tables 3, 4 and 5 warrant attention and should constitute the basis for useful S and T indicators. Surveys such as those summarized in tables 2-5 are also important for what the lists of contracts seem to omit rather than include. Thus, the lack of contracts for environmental facilities is significant and warrants investigation.

Intensive infrastructure building is evident in all countries of the region. In efforts aimed at measuring the national or sectoral levels of S and T demand, it will be essential to look more closely at what is involved in contracts directed at "services and infrastructure". Annex table C.1 provides a more detailed distribution of contract values across sectors. Annex table C.2 also provides a detailed distribution of the values of contracts relating to segments of industry.

In general, national and sectoral bodies concerned with capacity-building in particular areas of the economy have an important role to play in information-gathering on, and analysis of, S and T demand. These bodies could include concerned government departments, as well as trade and industry federations and professional associations. Reviewing the performance of such bodies is an essential part of S and T performance measurement.

[1/] Unpublished results. This survey was conducted by the ESCWA secretariat on the basis of information published on contracts concluded in the region by the *Middle East Economic Digest* during the years 1992-1995. Information presented in the table pertains to contracts in which the term "consultancy" was explicitly mentioned in the title or the subject of the contract. Many other contracts might involve consultancies of some kind or another. Thus, total sums dedicated to consultancies by the ESCWA member countries may be much higher than the figures quoted in the table. The latter figures should be viewed merely as providing an illustration of the type of information that may be readily available for the formulation of more specific S and T indicators [11].

TABLE 2. CONSULTANCY CONTRACTS REPORTED AS CONCLUDED BY ESCWA MEMBER COUNTRIES DURING THE FOUR-YEAR PERIOD 1992-1995: DISTRIBUTION OF NUMBERS OF CONTRACTS AND TOTAL VALUE ACROSS COUNTRIES

(*Millions of US dollars*)

Country	No. of contracts	Value	Sectors
Egypt	7	162.6	Infrastructure, Agriculture and Fishing, Transport and Industry
Jordan	4	2.38	Infrastructure and Industry
Kuwait	4	30.23	Infrastructure and Services
Lebanon	4	15.67	Infrastructure and Transport
Oman	2	13.8	Infrastructure and Tourism
Qatar	1	10	Industry
Saudi Arabia	3	220.9	Infrastructure, Industry and Services
Syrian Arab Republic	2	3.28	Infrastructure and Industry
United Arab Emirates	5	169.6	Infrastructure, Transport, Industry and Services
Yemen	1	0.56	Services
Total	33	629	Agriculture and Fishing, Infrastructure, Industry, Services, Tourism and Transport

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published on contracts concluded in the region by the *Middle East Economic Digest* (MEED) during the years 1992-1995.

Note: For further information on the sectors in this table, see annex table C.3 in the present study.

TABLE 3. CONSULTANCY CONTRACTS REPORTED AS CONCLUDED BY ESCWA MEMBER COUNTRIES BY MEED DURING THE FOUR-YEAR PERIOD 1992-1995: TOTAL VALUE ACROSS SECTORS

(*Millions of US dollars*)

Sector	No. of contracts	Contracts value
Infrastructure	13	452.9
Agriculture and Fishing	1	88
Transport	5	58.1
Industry	9	17.1
Services	4	9.5
Tourism	1	3.4
Total	33	629

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published on contracts concluded in the region by the *Middle East Economic Digest* (MEED) during the years 1992-1995.

Note: For further information on the sectors in this table, see annex table C.3 in the present study.

TABLE 4. DISTRIBUTION OF CONTRACTS REPORTED AS CONCLUDED BY THE ESCWA MEMBERS DURING THE FOUR-YEAR PERIOD 1992-1995

(Millions of US dollars)

Country/area	Total value of contracts[a/]
Bahrain	2 261.46
Egypt	7 041.19
Gaza/West Bank	151.31
Iraq	30.83
Jordan	1 989.87
Kuwait	7 172.57
Lebanon	2 845.23
Oman	2 120.23
Qatar	3 513.59
Saudi Arabia	18 434.22
Syrian Arab Republic	2 400.52
United Arab Emirates	9 409.17
Yemen	790.77
Total	58 160.95

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published on contracts concluded in the region by the *Middle East Economic Digest* (MEED) during the years 1992-1995.

a/ Areas covered: Infrastructure, Transport, Tourism, Services and Industry.

TABLE 5. SECTOR DISTRIBUTION OF CONTRACTS CONCLUDED BY THE ESCWA MEMBERS DURING THE PERIOD 1992-1995

(Millions of US dollars)

Sector	Sector total
Agriculture and Fishing	351.57
Defence	4 734.74
Economic restructuring	37.00
Industry	17 904.37
Infrastructure	18 615.90
Services	6 422.73
Tourism	895.73
Transport	9 198.92
Total	58 160.95

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published on contracts concluded in the region by the *Middle East Economic Digest* (MEED) during the years 1992-1995.

Note: For further information on the sectors in this tables, see annex table C.3 in the present study.

V. INDICATORS OF INTERNATIONAL COOPERATION IN S AND T

In principle, international cooperation is possible in a wide variety of S and T activities. Cooperation in higher education and technical training of nationals from the ESCWA member countries is an ongoing activity. Several, mainly governmental, organizations in the region keep records of students and professional staff sent on study and technical training tours for a variety of purposes. It should be a relatively simple task to collect and analyse such data in order to chart current orientations and assess available information on the expected outcome.

In particular, technical training is often associated with technology transfer operations. The fact that cooperation in technology transfer tends to be tied to large investments will ultimately place more or less strict limits on this mode of S and T cooperation. Cooperation in research does not necessarily suffer from such restrictions. Hence, it is useful to consider the nature of indicators capable of providing a measure of the extent of this form of cooperation and to identify patterns to enable policy developments for optimal results.

International collaboration in scientific research is generally on the increase, particularly in relation to research in the basic and applied sciences in countries with limited financial and manpower resources.[1/] Such countries will of necessity be in possession of relatively small S and T budgets and knowledge bases. It stands to reason, therefore, that researchers should look abroad for additional resources and expertise. Several of the smaller industrialized nations report a considerable increase in the percentage of joint publications with researchers in other industrialized countries [12].[2/] The degree of international cooperation in research appears to be particularly significant in the case of cutting-edge research. In addition to the increased cost of equipment needed for conducting research in new electronic and optical materials, for example, there is the need to obtain scarce expertise in highly specialized areas for the interdisciplinary research involved.

On the basis of charts indicating the extent of research collaboration with the various partners and in the various research fields, it is possible to construct patterns establishing the groundwork for policy directives aimed at enhancing the efficacy of research collaboration.

1/ The percentage of research papers produced as a result of international cooperation in countries in Europe, for example, can be substantial—more than 20% of all papers produced by Netherlands researchers in the natural sciences, for instance [12].

2/ For publications produced by researchers working in institutions in the Netherlands during the years 1993-1994, it was reported that more than 17% of the addresses in (partially) Netherlands scientific papers refer to foreign organizations—about 50% more than a decade earlier [12].

VI. SCIENCE AND TECHNOLOGY INDICATORS FOR THE ESCWA MEMBER COUNTRIES

Whether intended, or merely a result of fortuitous parallel thinking on the part of economists and engineers engaged in the analysis of S and T capabilities during the 1950s and 1960s, science and technology indicators developed and used by a number of international, regional and national institutions carry the analogy with "engineering systems" a step further. Thus, at the conceptual level, S and T indicators tend to be viewed as instruments which may be used to characterize and assess the efficiency of a given S and T system through analysis of its input, output, intrinsic processes and interactions with other systems within the socio-economic environment.

However, the systems of S and T indicators currently in use suffer from a number of other important shortcomings that tend to limit the utility of these indicators as policy instruments. These shortcomings are summarized in the following sections under headings that spell out the principal issues at stake.

It stands to reason that a system of indicators that is applicable in a wide variety of situations and is, at the same time, completely devoid of any imperfection is an unattainable ideal. The following brief review of some of the major shortcomings of traditional systems of indicators may nevertheless be of considerable value in producing better interpretations of the results of their application and could constitute a step towards a new generation of S and T indicators. The summaries will focus on those aspects of S and T performance measurement that are of special relevance for the ESCWA member countries.

A. THE STATE OF OVERALL SOCIO-ECONOMIC DEVELOPMENT

Indicators in present use are generally insensitive to the stage of development that characterizes a given socio-economic setting and the S and T system it is supposed to nurture. Interpreted somewhat crudely, this may be seen as implying the arguable notion that all science and technology is beneficial for all socio-economic settings. S and T capacity-building—particularly in the developing ESCWA member countries—is, more often than not, carried out under resource and time pressures involving technology inputs developed in entirely different socio-economic settings. Hence, alternative approaches to those used by the developed countries should be adopted to measure progress in capacity-building. This is not meant to negate the trend towards "techno-globalism." As noted by Archibugi, although "a globalised economy is transforming the landscape for the generation and diffusion of innovation ... this does not appear to decrease the importance of national characteristics nor, even less, of national institutions and their policies.[1/]

In addition, there is now a strong tendency to consider not only technology but also science as "socially constructed" [16]. However, what will be needed, in a vast number of instances, falls short of remodelling science, or even technology. What will probably be needed, in most cases, may not exceed the capacity for the adaptation of technology and the ability to carry out applied science and endogenous technology development in a manner that takes into account socio-economic development objectives. It is such abilities that a finely tuned set of S and T indicators should be capable of measuring.

In seeking to devise indicators that are sensitive to the region's particularities, it is important to redefine some of the basic notions upon which strategic S and T planning should be carried out. Porter's definition of technology strategy [17] requires that three broad issues be addressed:

[1/] D. Archibugi and J. Michie, "Technological globalisation or national systems of innovation?", *FUTURES: the journal of forecasting, planning and policy*, vol. 29, No. 2, March 1997 (Pergamon), p. 122.

"What technologies to develop;
"Whether to seek technological leadership in those technologies;
"The role of technology licensing."[2/]

With regard to ESCWA member countries, it will be necessary to include the need for selectivity as a factor in the adaptation, blending and diffusion of technologies, in addition to technology development. As to the issue of seeking positions of technological leadership, it is important to realize that it is possible, as has been demonstrated even by examples from the developing countries, to achieve leadership in certain areas by capitalizing on a set of local conditions that aid sustained development in specific technologies. A possible example in the case of some countries could be in technologies that relate to the cultivation of endogenous medicinal plants as well as the extraction and processing of their active ingredients. The accumulation of experience in desalination technologies and certain branches of petrochemicals makes them areas in which positions of technological leadership may be attained.

The ESCWA members should focus on the role of technology licensing and how regulations might favour certain licensing agreements in contrast with others in their individual technologies and collective strategic efforts.

Assessing the capabilities of a given environment to generate, sustain and make use of S and T capacity is an extremely important issue in measuring S and T development. Since a meaningful description of this environment is generally difficult to achieve on the basis of numerical data alone, it may be necessary to resort to other methodologies that are more amenable to a descriptive, as well as a numerical, approach.

Although output indicators could play an important part in relation to both R and D, as well as higher educational systems, certain local factors may curtail their utility. Government regulations, for example, may render certain indicators inapplicable or meaningless. Thus, the success or otherwise of a given higher educational or vocational training system in providing its graduates with qualifications that readily secure employment may be of limited value if, for example, regulations stipulate that graduates from a particular stage of the educational process must be absorbed *en mass* into public sector institutions. This has been the case in a number of ESCWA member countries. However, efforts at academic reform undertaken in the late 1980s and the early 1990s, in several of these countries should produce important changes in the present scene. In general, indicators developed to measure S and T performance should be sensitive to the legislation governing the S and T system's operations. Legislative and regulatory frameworks can exert a profound impact upon the quality and the productivity of R and D and higher education, as well as the variety of technical services that constitute an essential part of the total S and T system in question.

B. Input versus output orientation

S and T indicators in current 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 whatever relevant information may exist concerning output and demand. In summary, it suffices to note the absence, from currently used sets of indicators, of elements that enable "closing the circuit" in the actual operation of S and T systems.

A number of ESCWA member countries are currently engaged in the formulation of S and T policy exercises. Although it may be too early to decide how the various national efforts will deal with the problem

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[2/] Rias J. Van Wyk, "Strategic technology scanning", *Technological Forecasting and Social Change: An International Journal*, vol. 55, No. 1, May 1997 (North-Holland), p. 22.

of quantifying and evaluating R and D output, it is probably safe to assume that the issue of R and D output will receive further attention in the coming few years. The increasing accessibility of international databases encompassing a variety of S and T publications, as well as enhanced publication activity in local S and T journals over the past few years, should provide future efforts in this domain with adequate material for more adequate coverage of R and D output.

C. Quantitative versus qualitative aspects of S and T development

The systems of S and T indicators in current use still do not contain adequate provisions for evaluating the qualitative aspects of an S and T system under consideration. This often constitutes a serious shortcoming in assessment exercises. Notwithstanding the importance of collecting and collating quantitative information on expenditure on higher education as well as R and D, the ratio of students to staff in university faculties and the ratio of administrative to technical staff in R and D centres, it is difficult on the basis of such information alone to ascertain the state of an S and T system. Quantitative information alone is not an adequate criterion on which to base a decision on how well an S and T system responds to national development priorities and how capable it is of dealing with challenges and making use of opportunities posed in the regional and international arena. It is only through qualitative assessment of higher education and R and D endeavours at the national and the institutional levels that the extent and nature of such responses may be ascertained.

In other words, what is needed is not simply to determine how much money is spent on R and D but on what sort of R and D is money being spent and what sort of results are produced. This is especially important in an environment that has not as yet developed clear orientations in S and T. It may be less important when R and D in a confined area is being dealt with, within a firm in a developed country environment. It is much more important when the S and T policy of an entire country is being considered. In the case of industrial R and D being carried out in a particular firm, close contact with corporate management, as well as the marketing and business departments, could provide important information on R and D performance in both areas. However, even in such an environment it is often necessary to resort to qualitative, as well as quantitative, measures of the performance of an R and D laboratory.

There will also be a need to introduce qualitative criteria that allow assessment of a country's ability to communicate and cooperate with S and T institutions outside its own boundaries. Qualitative criteria that spell out the responsiveness of a country's and T system to the demands of business enterprises will also be essential in forging stronger links between the components of the national S and T systems and production/service activities.

Apart from sensitivity to the characteristics of the general socio-economic environment of a given S and T system, a useful system of indicators should also reflect the particularities of the very system it is designed to assess. It should thus provide reliable and detailed information on the socio-economics of the S and T system itself. This is obviously impossible to carry out on the basis of quantitative indicators alone.

There is a class of indicators, termed "quantitative-subjective metrics" by Werner and Souder, that is based on "intuitive judgements" expressed in numbers. Thus, specialists opinions are solicited on an aspect of R and D activity in a particular area that is not accessible to straightforward measurement because of the degree of difficulty or complexity of a given research problem. The results for a number of problems in the same or in similar areas are then graded by assigning numerical values to specialists opinions. The opinion of a number of experts is sometimes sought in order to reduce the subjective nature of views made by a single expert or a small number of specialists. Instances in which quantitative-subjective indicators are used to reinforce straightforward quantitative indicators have been reported [4].

It is interesting to note that, the more "fundamental" a research problem is, the more it will be necessary to resort to qualitative assessment, with or without conversion of the results of such assessments into a quantitative-subjective format. Conversely, the more "applied" and the closer the problem is to the product and process development stage, the more it is possible to resort to quantitative-objective metrics [19].

At the institutional level, qualitative indicators include timeliness of output, quality of planning and management of resources, as well as intrinsic attributes of the output concerned, such as thoroughness of scientific or engineering analysis.

At the level of individual researchers and small R and D units, qualitative indicators can take one or more of the following forms: self or group evaluation, supervisory and peer ratings, and external auditing.

However, it should not be forgotten that quantitative indicators may still be preferred in a variety of situations on account of their reference to countable entities and, hence their presumed objectivity. In any case, it should be borne in mind that qualitative methods can be more expensive than quantitative methods [13].

Finally, an often ignored advantage of qualitative indicators is the fact that they can catalyse useful contacts, accelerate learning processes already in place and contribute to the creation and sustainability of a quality culture. This is particularly the case when their application involves inter- and intra-institutional expositions, demonstrations and discussions.

D. Relevance to objectives

The purpose for which statistical information is collected, ideally, plays an important part in devising indicators, data collection and interpretation methodologies. In general, the design of a particular set of indicators will determine, to a large extent, their usefulness for a particular task. A review of available indicators, and the data collected with regard to them, indicates that the conclusions based on them would be of great interest in studies of a historical or general character. S and T indicators have thus often been used as a paintbrush with which the evolution of a particular S and T system is depicted. Using S and T indicators as a tool for generating policy guidelines, as well as predicting trends relating to the performance of these systems, may have been less common, however. Chief among the reasons for this is the patent inability of the numerous sets of indicators to generate reliable normative inputs for policy considerations.[3/] They may prove to be of even more limited utility as bases for sector and discipline-specific studies aimed at policy formulation and reviewing.

It may be pointed out that, in common with economic indicators, a "system" of S and T indicators should make it possible to assess the past performance of a "system" under consideration, as well as provide valid, if only rough, predictions concerning its future behaviour. It is only as such that a system of indicators may be of utility as a tool for extracting the information needed for policy formulation and decision-making exercises.

E. New technology inputs

Indicators in present use are of limited utility as bases for the study of how capacity-building is proceeding in respect of selected disciplines and sectors. It is not possible, for example, to determine on the basis of

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[3/] The fact that S and T policies are still at an embryonic stage in several of the developing countries, including many ESCWA member countries, should also be noted in this respect.

aggregate R and D spending in a given field, to what extent R and D activities, or for that matter higher education activities, in that field tend to be based on new methodologies of investigation and instruction respectively.

Currently used indicators do not reflect the extent to which the new computational, information and telecommunications technologies are being introduced into the national S and T systems. The issue of the availability of microcomputer systems, for example, may be addressed from both a quantitative angle, i.e. number of computers per institution or researcher, and a qualitative aspect taking into account the novelty of computational devices and the quality of available software and support services.

Similar considerations apply in the case of computerized telecommunications, the possibilities of which are open to personnel involved in R and D and higher education activities. Information could also be collected on the availability of Internet and other linkages, both national and local, between universities, R and D centres, libraries, central statistical offices, and extension services.

F. Focus on priority areas

The general nature of the indicators being used and, subsequently, of the data collected, makes it impossible to ascertain the degree of focus achieved in dealing with particular priority areas for national development. The neutral character of S and T indicators in current use can be of great benefit in addressing "bulk properties" of S and T systems. Targeting aspects that are directly relevant to priority issues, such as S and T for environmental protection, combating desertification, and enhancement or conservation of water resources, requires a different set of indicators. Priority issues are elaborated and reviewed at length in national socio-economic development policies. The lack of appropriately specific indicators generally weakens the link between overall policies and those policies that determine the path taken by S and T development. Concern for the environment and emphasis on the sustainability of development in industry, agriculture and the services sectors should influence the choice of indicators used to measure the performance of S and T systems within this climate.

In addition to overall national priorities, S and T indicators should address special priorities for the development of the S and T system itself. Countries and institutions suffering acute manpower shortages may therefore introduce special indicators to measure the manner in which they approach set targets in this respect. These indicators could then facilitate the institution of policies aimed at remedial action.

G. Global change

For the most part, systems of S and T indicators in use by concerned national, regional and international bodies appear to reflect only to a limited degree the global changes that should also affect S and T development. The move towards trade liberalization and the introduction of international quality and environmental standards should, ideally, have a massive impact on the orientation of S and T activities around the globe. R and D activities, higher education programmes, technical training curricula, and the type of calibration and certification services provided to production enterprise should also be influenced by moves aimed at compliance with emerging international and regional norms. However, currently used S and T indicators do not provide any feedback on the responses generated by S and T systems to inherent threats and opportunities.

The responses of national S and T systems to global change can be measured. Measurement can focus on issues such as the existence, as well as the extent and level of activity, of quality assurance organizations, calibration and standardization bodies, quality certification bodies, and legislative and enforcement measures to ensure compliance with environmental standards stipulated by concluded and draft international agreements. Compliance would be ensured through the acquisition and the adaptation of environmentally sound technologies (see box 9).

Another indicator of a healthy response in this area would be the extent of technology blending that is taking place in order to upgrade the performance of sectors encumbered with obsolescent technologies. The modern management and control and telecommunications technologies introduced in production and services activities are also S and T-related responses that gauge readiness for dealing with global change. These and other parameters should be addressed at the levels of governmental legislation and the individual enterprise, as well as the concerned trade and industry federations and professional associations.

VII. INDICATORS FOR S AND T POLICY FORMULATION

The present study has briefly reviewed some of the major shortcomings of current S and T indicators. It should be noted that, in a number of cases, the difficulties encountered in measuring the performance of a given national S and T system may often be due to inherent inadequacies within the system itself. To deal with these inadequacies, concerted action should be taken by governmental and non-governmental organizations, and public and private enterprises, and cooperation with regional and international organizations should be enhanced. Coordinated action involving such a variety of institutions necessitates a firm policy base at a national level. A number of ESCWA member countries have already taken steps in this direction. Egypt, Jordan, Lebanon and Saudi Arabia, for example, have either formulated, or are in the process of formulating such policies.

The design of S and T indicators, at the national and institutional levels, may be carried out with reference to specific development needs of sectors and even segments. More usually, however, indicators are used principally in national and corporate policy exercises to lend support for particular approaches to future action targeting overall development. As noted above, to do this well, the indicators chosen and the information available must allow for maximum predictive value. This necessitates taking into account expected changes in end-user fields, as well as in adjacent and support areas of activity. The following section of the text focuses on sets of object-oriented national S and T indicators of particular interest to the ESCWA member countries.

As noted above, several ESCWA member countries are engaged in setting up, or reformulating their national S and T policies. Reliable S and T indicators may be an invaluable asset in such an exercise. In addition, a few countries in the region have also taken steps towards the establishment of national technology policies. A key issue in this respect, is, first, to reserve a central position in such policies for information on key components of the national S and T system, and, secondly, to integrate the idea of S and T performance measurement within such policies.

In general, however, almost all the indicators proposed and utilized at the macro level by organizations such as UNESCO and OECD can provide an excellent background for national S and T policy planning. In addition, however, there is a need to introduce indicators that enhance the link between S and T policy and priority issues in sustainable development. Stronger emphasis should be placed on building linkages between components of the S and T system and business enterprises. Making better use of global developments in the sourcing and exchange of information is another urgent priority that is not adequately addressed by systems of "conventional" indicators. For all of these reasons, macro-level indicators will have to be supplemented by indicators that target specific priority sectors, segments, disciplines and support structures.

Predicting future available manpower resources with capabilities for supporting R and D activities in a particular area, for example, should be a relatively simple matter, given indicators with sufficient resolving power, in terms of the level of manpower training and orientation. It may also be possible to assess, with some confidence, the levels of funding which may be made available for R and D activities in a particular area on the basis of similar analyses. Greater difficulties, however, will be encountered in predicting the results of R and D in a given area on the basis of the human, financial and information resources made available, including the prevailing state of knowledge. In certain areas of cutting-edge research, the ability to predict possible outcomes is important for making future investment-related decisions. More sophisticated considerations that require delving into the intricacies of the research being conducted will often be necessary for such purposes. It is particularly in such areas that S and T indicators must give way to specialists' studies, which may, nevertheless, have relatively wide margins of error.

At any rate, the predictive value of well-designed S and T indicators may have benefits that surpass the S and T system, extending to other areas of socio-economic activity, including technology transfer as well as investment in the industry, agriculture and service sectors.

Boxes 5-10, list a number of qualitative and quantitative indicators which may correspond to S and T policy/strategy planning needs. These indicators, which address both output as well as input considerations, should, in principle, ensure greater success in the measurement of S and T performance. The following are comments on some of the main aspects of the indicators listed in boxes 5-10.

Policy-related indicators: The inclusion of national policy-related parameters, in relation to higher education as well as R and D, may seem archaic given the drive towards further liberalization and lifting of government controls over all sorts of activities. In this connection, it is well to remember that national policies will continue to be of considerable importance, even in the liberalized global superstructures of tomorrow. National policies are still needed to formulate integrated responses to global and regional changes, as well as to accommodate the emergence and diffusion of a number of influential technological trends [19]. Numerous examples of successes achieved through policy intervention may be found in Japan, the United States and Europe [20]. Naturally, cases in which ill-conceived policies led to adverse effects may also be cited. However, the ultimate lesson to be drawn from both types of experiences is the need to consider seriously the impact of policies on S and T development. It should also be noted that government involvement in S and T policy formulation and implementation is intensifying, rather than diminishing as might be expected on the basis of the much publicized trend towards liberalisation. A variety of direct and indirect means are used as vehicles for governmental action in this respect. It is not the centralized approach that characterized policy planning in the countries of Eastern Europe in the past that is now being used. On the contrary, approaches are often adopted as the result of intensive consultations and focus on providing direct grants, incentives, tax rebates, and government support in training and re-training activities.

Finally, the very process of policy formulation will constitute, if properly conducted, an invaluable opportunity for learning, interaction and cross-fertilization of ideas.

Conformity with traditional statistical indicators: It is important to note that the S and T indicators presented in boxes 5-9, do not, indeed cannot, always conform to the norms adopted by straightforward and conventional statistical indicators. In a number of cases, information that is descriptive or qualitative in nature must be addressed. However, in a number of other cases, such information should make it possible to conduct numerical assessments in a manner similar to that used for the above-mentioned conventional indicators. Thus material on national information networks must of necessity be descriptive and qualitative in part. However, once the fact that such a network exists has been established and, its areas of interest, its components and protocols characterized, it should be possible to go into quantitative details on the number of nodes connected to its hub, the storage capacities available, and the frequency with which information is updated. However, the task of making such information comparable is one that still needs to be addressed.

Support for small and medium enterprises: Indicators that provide support for businesses, and in particular small and medium enterprises (SMEs), are viewed as essential. The current technological revolution is engendering a vast variety of products, processes and related opportunities. Coupled with trade liberalization, this revolution will enormously enhance competitiveness. Local enterprises will therefore need much greater support in identifying and making use of opportunities for investment in new technologies, and indicators that measure this support will be of immense importance. Emphasis on SMEs is necessary, since most local enterprises in the ESCWA member countries are in this category, and since they will generally have the most difficulty in meeting their S and T needs.

Box 5. A set of quantitative and qualitative higher education indicators

NATIONAL VIEW

Characteristics of existing higher education policies: themes, major areas of emphasis, relevance to specific areas of national overall development policy, as well as S and T policy/strategy;

Expenditure on higher education as a ratio of GDP, distribution across SET (Science Engineering and Technology) departments, as well as share per student in SET specializations and across specializations and qualification levels;

Library facilities and links to national and international databases and information centres, as well as regulations governing the use of such links;

Number of universities and other institutions of higher education and vocational training and their distribution across:

(a) Year of establishment;
(b) Size of student and teaching bodies and relevant ratios;
(c) Total number and types of courses offered: part- and full-time, "sandwich", as well areas of specialization covered;
(d) Range and type of degrees offered;

Number and orientations of science, engineering and technology (SET) departments: their distribution across disciplines and specialisations with emphasis on priority areas of interest at the national level and areas of new and advanced areas in science and technology;

Student enrollment by level of higher education and field of study within their home countries , as well as abroad, with particular emphasis on students from other parts of the region;

Professorial, teaching and assistant staff in SET departments, by specialization, qualifications and R and D areas of activity in which they are involved;

Course completion rates across disciplines and areas of specialization;

Success rates in acquiring jobs at the end of courses of higher education, by area/discipline, university/department and employing sector;

National placement services for graduates of higher education and their links to potential employers;

Measuring the past, the present as well as the future: In order to be meaningful, some of the indicators and sources of indicators shown in boxes 5-10 should be applied to past, present and future planning periods. This is more readily achievable in the case of S and T institutions. At the institutional, as opposed to the national level, it will be possible to obtain a more dynamic picture of developments. Furthermore, at such a level certain policies may be more readily modified and fine-tuned to achieve specific targets.

Box 6. A set of quantitative and qualitative R and D indicators

NATIONAL VIEW

Information on National S and T policy or strategic plans and related institutions:

- Major components, themes and areas of focus, short- and medium-term objectives;
- Numerical targets and dates set in relation to resource allocations from GDP;
- National legislative and regulatory framework for R and D institutions/activities;
- Methodologies worked out for securing resources and following up on progress;
- Existence and orientations of bodies engaged in technology scanning and assessment at national\sectoral levels; date established and details of their linkages and operating methodologies.

Number of R and D institutional units, their missions, affiliations and distribution over principal areas of R and D activity;

Number of FTE (full-time equivalent) researchers and their distribution across R and D fields, by qualifications and type of institution (governmental, semi-governmental, private, etc.);

R and D expenditure:

- In absolute terms and as share of GDP;
- Share by researcher by institutions/units and fields of research;
- Contributing bodies, and institutions in relation to particular R and D institutions/units and R and D fields;

Information on the existence, and extent of coverage and participation, in national information networks, as well as expenditure allocated to securing information as well as establishing linkages to other information networks/sources;

Volume of total computing capabilities available to all R and D institutions and related activities across fields of activity and institution with information on generations and compatibility;

Number of total support staff and their distribution across R and D institutions/units, R and D fields, as well as by qualification levels;

Number of special R and D initiatives undertaken at the national level: aims, financial and other resources, cooperating bodies from industry, agriculture and the service sectors, as well as targets achieved;

Initiatives and modes of assistance extended to businesses, concerning technology assessment and acquisition, with emphasis on the needs of small and medium enterprises;

Number of R and D publications across institution types, R and D fields, as well as publication/dissemination media, i.e. local and international journals, as well as national, regional and international seminars, conferences and symposia;

Number of patents registered and applied for, across fields of R and D and areas of application;

Availability, number and fields of activity of national technical facilities for R and D support, scientific equipment building and maintenance centres, laboratory equipment and materials manufacture/packaging facilities;

Information on the activities of patent examination and patenting bodies and their linkages to R and D and higher educational institutions;

Information on specialized R and D networks and special agreements for R and D collaboration and information/expert exchange within the country and with other countries/institutions.

Box 7. A set of quantitative and qualitative indicators for higher educational institutions

INSTITUTIONAL VIEW

- Organizational structure:
  Faculties, affiliated centres and institutions;
- Courses offered and course planning methodologies:

(a) Particular emphasis on contents relating to selected technologies considered vital to national development and specific new and advanced science and technology areas;

(b) Types of courses and levels of qualifications offered with particular emphasis on the availability of part-time and "sandwich" courses;

- Expenditure as share of national higher education budget /GDP and share of students across specializations and degree levels;

- Availability, budgets allocated for maintenance of, and usage rates of existing links to national information networks and international databases and information resource centres, as well as regulations governing the use of such links and their availability to students and teaching staff;

- Library volumes, periodicals and information resources: their distribution across disciplines, as well as indications of budgets allocated for building up and replenishing library acquisitions;

- Information about links to information sources at the national and international levels and the availability of such links to staff and students;

- Total volume of computing capabilities and information about its distribution across faculties/departments and accessibility to staff and students;

- Numbers of teaching and assisting staff and their distribution across fields of higher educational activity and ratios to students at various levels of the educational/training process as well as their distribution across qualifications;

- Information about type of contacts maintained with potential employers of graduates and the involvement of the former in curriculum design and teaching methodologies;

- Information about cooperation agreements with sister institutions in the region, as well as internationally, with emphasis on possibilities and conditions for the exchange of students and staff as well as collaborative R and D;

- Information about the availability of R and D facilities and R and D fields actively pursued, or to be taken up, within past, present and future planning periods by members of the teaching staff;

- Success rates in acquiring jobs: distribution across courses of higher education, by area/discipline faculty/department and employer;

- Availability of graduate placement services and links to potential employers.

Box 8. A set of quantitative and qualitative indicators for R and D organizations

INSTITUTIONAL VIEW

- Mission, organizational structure and affiliations;
- Planning and management methodologies and relevance to national S and T policies as well as issues of regional and global concern;
- Research fields actively pursued within past, present and future planning periods;
- Number of FTE (full-time equivalent) researchers and support staff, by qualifications and distribution across R and D areas;
- Institution's R and D expenditure:
  - (a) Share of national R and D expenditure;
  - (b) Distribution across expenditure items, staff salaries, investment, and running and maintenance costs;
  - (c) Investment in new facilities and equipment across fields.
- Distribution across sources of funding: research contracts, services, donations and royalties;
- Data on information resources:
  - (a) Library volumes and periodicals;
  - (b) Availability of CD-ROM databases;
  - (c) Links with national information networks and international information sources and types of arrangements covering such links;
  - (d) Annual budgets allocated for acquisitions.
- Volume and generations of available computing capabilities across fields of activity and in proportion to R and D staff;
- Information on project planning, quality assessment methodologies and systems of incentives adopted in the institution;
- Number of projects carried out and contractual arrangements concluded across areas of activit and for client groups within the previous and present planning periods, as well as information on projects planned for the future planning period;
- Number of publications and patents applied for and obtained:
  - (a) By various sub-units or R and D groups;
  - (b) Across R and D fields;
  - (c) By areas of application;
  - (d) Authorship attributions and available citation information.
- Information about interaction with institutions of higher education and production/services enterprises in the public and private sectors and contractual arrangements covering such links;
- Information on cooperation arrangements with production and services sector enterprises in the public and private sectors;
- Information about cooperation and networking arrangements with other R and D institutions in the country as well as outside;
- Information about S and T meetings and training activities organized and attended by staff from the institution across fields of activity;
- Data on interactions and regulations governing joint activities with S and T support institutions including consultancy and design offices, patenting and licensing bodies;
- Data on S and T services offered by the R and D institution/unit across organizational entities and client groups.

S and T initiatives: On the issue of special R and D initiatives, it is important to stress the need for indicators designed to measure governmental and business support. It should also be borne in mind that the role of Governments in the ESCWA member countries may not be minimal. It is noteworthy that the role of Governments even in economies that thrive almost entirely on private enterprise is by no means negligible.[1/]

Box 9. Sources of quantitative and qualitative indicators for S and T support institutions

NATIONAL VIEW

- National policy and legislative considerations governing the creation and activities of the various types of S and T support institutions;
- Numbers, affiliations and dates of establishment of S and T support institutions, including consultancy and design offices, calibration, standardization authorities, testing and certification laboratories, quality assurance bodies, ISO (International Organization for Standardization) accreditation organizations;
- Manpower numbers across types of support institutions and qualification levels;
- Financial resources and their distribution across funding sources, types of support institutions and areas of activity and indications of revenues collected against services rendered;
- Library volumes, periodicals, patent documentation as well as other information resources available to S and T support services and their distribution across types of S and T support institutions;
- Links to national, regional and international information networks as well as other sources of information, including international patent offices and standardization organizations;
- Information, in each class of S and T support institutions:

  About types of support services rendered;

  Distribution of activities across fields of activity and client groups: by activity numbers and fees rendered or contracts concluded;
- Specialized equipment and computing facilities available to S and T support services: in terms of numbers, generation and distribution across areas of operation.;
- Institutional services and conditions under which services are offered across the various types of institutions;

Non-R and D contributions to S and T: The fact that S and T development owes a great deal to non-R and D inputs argues for the inclusion of a set of indicators which may be used as a basis for measuring the performance of S and T support institutions, such as calibration, standardization and quality assurance bodies.

At the institutional level, non-R and D expenditure will be reflected in activities in, and expenditure on, patenting, licensing, design, pilot production, special tool design, modifications to existing production lines and manufacture, training and marketing. A recent survey in the Netherlands reveals that expenditure on

[1/] In the United States, for example, the following initiatives, agencies, programmes and projects are known to have government backing: the Technology Reinvestment Project, the Advanced Research Projects Agency, the Small Business Innovation Research centre, the Small BusinessTechnology Transfer Pilot Programme, Technology for International Environmental Solutions, Cooperative Research and Development Agreements. The small business orientation in at least two such initiatives is apparent [21].

product-related R and D amounted to only about one quarter of total expenditure on product innovation. Furthermore, the same survey has revealed that roughly half of the total expenditure on product-related innovation is made in fixed assets. Nevertheless, charting the growth and the performance of institutions charged with providing the various kinds of S and T services needed, such as calibration, standardization, certification, and quality assurance, is of considerable importance. In the ESCWA member countries, such institutions are mostly in the start-up stage. Their impact on these countries' economies is magnified by the important tasks they have to perform in order to comply with the new liberalized global trade regulations and to enhance competitiveness through quality improvement.

S and T indicators for enterprises: The fact that enterprises in ESCWA member countries are, by and large, of small and medium size means that they may undertake little, if any, R and D activity. In upgrading the levels of technology for such enterprises, emphasis will be on the introduction of new information technologies, and obtaining linkages with international telecommunications networks in order to facilitate information acquisition as well as marketing and distribution. However, in working towards these goals, as well as in carrying out R and D activities of a pre-competitive nature for the benefit of groups of enterprises,[2/] enterprises will have to rely on Governments, federations of producers, and chambers of agriculture, commerce and industry as well as professional associations.

Invoking sector-specific indicators: Indicators in common use address the totality of S and T systems. Developing "customized" sets of S and T indicators to serve policy formulation and implementation in certain priority areas may be necessary. Such is probably the case in certain areas of industry in general. The pharmaceuticals industry in some of the ESCWA member countries is a case in point. A set of indicators specially designed to reflect present and future S and T needs of this industry would be invaluable in the design of technology acquisition policies, frameworks for alliances and coordinating local R and D plans.

[2/] Examples of areas where this will be required in the ESCWA member countries include the development of environmentally sound technologies for groups of industries, such as in leather tanning or dairy production.

Box 10. Sources of quantitative and qualitative S and T indicators for enterprises

INSTITUTIONAL VIEW

Area of activities and objectives;

Management and planning, with emphasis on technology development issues;

Affiliations and links to other firms, S and T institutions and to technology sources in and outside the country;

Description of production, packaging, marketing and distribution methodologies, emphasizing issues such as level of automation;

Manpower numbers and profiles;

Numbers and educational levels (qualifications):

- On shop floor (for the field);
- In management and planning;

Managerial, manpower and financial resources devoted to technology development and upgrading:

- On annual bases for past, present and future planning period;
- Types[a/] of activities conducted with the purpose of technology upgrading and expenditure on each category, including technology scanning, assessment and training programmes for various personnel levels concerned with technology upgrading;
- Time covered by technology upgrading programmes;
- Assistance received from other institutions including government departments and trade federations;
- Assessment of savings/losses incurred owing to previous technology upgrading exercises;
- Level of diffusion of computer and telecommunications capabilities in various areas of operations;

R and D and other related activities both in-house and in cooperation with other institutions;

Information resources needed, and available, to the enterprise:

- Areas where most information needs occur;
- Type and extent of assistance provided by various bodies, including government departments, national information centres, trade and industry federations, regional and international organizations;

Pilot activities, testing and calibration facilities possessed and utilized by the firm;

Quality control (QC) activities:

- Quality control facilities, and operations (volume of QC operations and adequacy of equipment);
- Type of link between QC facility and management;
- Relations with governmental and trade bodies concerned with QC and related issues (such as calibration, testing and certification bodies).

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a/ For example, purchase of new machinery, introduction of computer control of production quality control or management, including marketing and distribution operations and introduction of environmentally sound technologies.

VIII. CONCLUSIONS

The present review of the S and T indicators being used by a number of national, regional and international organizations confirms the need for the inclusion of more qualitative and output-related indicators. It is undeniable that developing and applying some of these indicators will be difficult, and it may justly be argued that difficulties are encountered even with the simplified quantitative indicators in use today. How then will it be possible to cope with the more complex sets of qualitative and quantitative indicators proposed?

Creating awareness of the need for more effective systems of S and T indicators is an essential first step, which must be followed by sustained effort on the part of dedicated groups of professionals and institutions at many levels. Collecting, collating and analysing data is a cumbersome task; it is one that often involves generalizations and inaccuracy. With regard to statistics on the S and T system, the task will, by its very nature, become even more difficult.

The new high-speed computer systems, and vastly more efficient software systems will make the task more manageable. Application of the emerging techniques of scientometrics and informetrics will also allow greater facility in the use of more complex sets of indicators. Nevertheless, the task is one that requires the allocation of resources at the national, the regional and the international levels.

Creating well-equipped national centres that specialize in the assessment of S and T capabilities will assist in the emergence of a regional perspective, which should in turn provide a better basis for informed cooperation, improved coordination and enhanced complementarity in building S and T capacity in the ESCWA member countries. Introducing and reinforcing performance consciousness at the institutional level will go a long way towards easing the task of national centres.

The goal of developing intelligent sets of S and T indicators should be part of an overall goal aimed at formulating more general sets of indicators that gauge national socio-economic development and, in particular, progress in building national systems for innovation. Such systems would naturally be far more complex and comprehensive than S and T systems [22]; however, detailed analysis of these systems would be more rewarding.

Finally, in the long run, the dissemination of improved S and T indicators will contribute to improving the performance of a system on whose vigour and vitality socio-economic development depends, and this is the ultimate goal of all work in this field.

Annexed tables

S AND T INDICATORS REPORTED FOR ESCWA MEMBER COUNTRIES IN THE UNESCO 1995 AND 1996 STATISTICAL YEARBOOKS

TABLE A.1. SELECTED SCIENCE AND TECHNOLOGY INDICATORS, 1995

Country	Year	Personnel engaged in R&D			Year	Expenditure for R&D		
		Scientists and engineers (per million population)	Technicians (per million population)	Number of technicians (per scientist or engineer)		As percentage or gross national product (GDP)	Per capita (in national currency)	Annual average per R&D scientist or engineer (in national currency)
Egypt	1991	458	340	0.7	1991	*1.0	*17	*36164
Jordan	1986	106	7	0.1	1986	0.3	1	13366
Kuwait	1984	924	343	0.4	1984	0.9	44	47097
Lebanon	1980	67	2	0.0	1980	-	8	122222
Qatar	1986	593	158	0.3	1986	0.0	17	29039

* Provisional or estimated data.

TABLE A.2. SCIENTIFIC AND TECHNICAL MANPOWER

Country	Year	Type of data	Total	Potential scientists and engineers		Potential technicians	
				Total	Female	Total	Female
Egypt	1990	ST	10436949	1573118	-	8863831	-
Jordan	1986	EA	-	30205	7280	-	-
Kuwait	1985	ST	131381	60398	-	70983	-
Qatar	1983	EA	9802	6302	1701	3500	1265

ST : Stock of qualified manpower.
EA: Economically active qualified manpower.

TABLE A.3. NUMBER OF SCIENTISTS, ENGINEERS AND TECHNICIANS ENGAGED IN RESEARCH AND EXPERIMENTAL DEVELOPMENT

Country	Year	Total	Scientists and engineers		Technicians	
			Total	Female	Total	Female
Egypt	1991	46022	26415	-	19607	-
Jordan	1986	447	418	54	29	6
Kuwait	1984	2072	1511	334	561	113
Lebanon	1980	186	180	-	6	-
Qatar	1986	290	229	58	61	2

TABLE A.4. NUMBER OF SCIENTISTS AND ENGINEERS ENGAGED IN RESEARCH AND EXPERIMENTAL DEVELOPMENT BY THEIR FIELD OF STUDY

Country	Year	Sex	Type of data	Total	Field of study					
					Natural sciences	Engineering and technology	Medical sciences	Agricultural sciences	Social sciences and humanities	Other fields
Egypt	1991	MF	FT+PT	54546	9620	7726	13677	7157	16366	-->
		MF	FTE	26415	4472	4092	6081	4617	7153	-->
Jordan	1982	MF	FT+PT	1241	310	340	118	92	381	-
Qatar	1986	MF	FT+PT	229	160	53	2	5	-	9
		F	FT+PT	58	57	-	1	-	-	-

-->: Not including military and defence data.
FT+PT: Full-time plus part-time.
FTE: Full-time equivalent.

TABLE A.5. TOTAL PERSONNEL ENGAGED IN RESEARCH AND EXPERIMENTAL DEVELOPMENT BY SECTOR PERFORMANCE AND BY CATEGORY OF PERSONNEL

			Sector of performance				
				Productive sector			
Country	Year	Category of personnel	All sectors (FTE)	Integrated R&D	Non-integrated R&D	Higher education	General service
Egypt	1991	Total in R&D	102296	12968	8113	61124	20091
		% by sector	100	12.7	7.9	59.8	19.6
		Scientists & engineers	26415	3805	772	14065	7773
		Technicians	19607	3400	1694	10347	4166
		Auxiliary personnel	56274	5763	5647	36712	8152
Jordan	1986	Scientists and engineers	418	23	-	255	140
		Technicians	29	4	-	15	10
Kuwait	1984	Total in R&D	2539	298	148	448	1645
		% by sector	100	11.7	5.8	17.6	64.8
		Scientists and engineers	1511	194	102	414	801
		Technicians	561	72	8	25	456
		Auxiliary personnel	467	32	38	9	388
Lebanon	1980	Total in R&D	-	-	-	206	-
		Scientists and engineers	-	-	-	180	-
		Technicians	-	-	-	6	-
		Auxiliary personnel	-	-	-	20	-
Qatar	1986	Scientists and engineers	229	-	44	185	-
		Technicians	61	-	7	54	-

TABLE A.6. TOTAL EXPENDITURE FOR RESEARCH AND EXPERIMENTAL DEVELOPMENT BY TYPE OF EXPENDITURE

Country	Reference year	Currency	Total	Type of expenditure				
				Capital	Current			Current as % of total
					Total	Labour costs	Other current costs	
Egypt	1991	Egyptian pound	*955273	*281463	*673810	*513086	*160724	*70.5
Jordan	1986	Jordanian dinar	5587	1287	4300	2348	1952	77.0
Kuwait	1984	Kuwaiti dinar	71163	8147	63016	57127	5889	88.6
Lebanon	1980	Lebanese pound	22000	-	-	-	-	-
Qatar	1986	Qatar riyal	6650	-	6650	-	-	100.0

* Provisional or estimated data.

TABLE A.7. TOTAL EXPENDITURE FOR THE PERFORMANCE OF RESEARCH AND EXPERIMENTAL DEVELOPMENT BY SOURCE OF FUNDS

Country	Reference year	Currency	All sources of funds	Source of funds			
				Government funds	Productive enterprise funds and special funds	Foreign funds	Other funds
Kuwait	1984	Kuwaiti dinar	71163 100	24437 34.3	45736 64.3	- -	990 1.4
Qatar	1986	Qatar riyal	6650 100	6650 100.0	- -	- -	- -

TABLE A.8. TOTAL AND CURRENT EXPENDITURE FOR RESEARCH AND EXPERIMENTAL DEVELOPMENT BY SECTOR OF PERFORMANCE

Country	Reference year	Currency	Type of expenditure	Sector of performance				
					Productive sector		Higher education	General service
				All sectors	Integrated R&D	Non-integrated R&D		
Jordan	1986	Jordanian dinar	Total	5587	315	-	3831	1441
			%	100	5.6	-	68.6	25.8
Kuwait	1984	Kuwaiti dinar	Total	71163	43324	1543	1480	24816
			%	100	60.9	2.2	2.1	34.9
			Current	63016	44148	-->	751	18117
			%	100	70.1	-->	1.2	28.8
Lebanon	1980	Lebanese pound	Total	-	-	-	22000	-
Qatar	1986	Qatar riyal	Total	6650	-	3300	3350	-
			%	100	-	49.6	50.4	-
			Current	6650	-	3300	3350	-
			%	100	-	49.6	50.4	-

-->: Data refer to scientific and technological activities.

TABLE B.1. SELECTED SCIENCE AND TECHNOLOGY INDICATORS*

Country[a/]	Personnel engaged in R&D[b/]			Expenditure for R&D		
	FTE researchers[c/] (per million population)	Support staff[d/] (per million population)	Support staff per FTE researcher	As percentage of GDP	Per capita (US dollar)	Share\ researcher (Thousands of US dollars)
Egypt	138	365	3	0.34	2.6	19
Jordan	87	190	2	0.28	3.6	41
Kuwait	190	326	2	0.22	27.8	146
Lebanon	58	69	1	0.15	1.6	27
Qatar	80	105	1	0.06	10.8	134
Bahrain	102	108	1	0.04	3.8	61
Iraq	52	47	0.9	0.04	1.6	54
Oman	26	93	4	0.05	3.7	144
Saudi Arabia	47	68	1	0.11	8	175
Syrian Arab Republic	25	114	5	0.11	1.1	42
United Arab Emirates	55	51	0.9	0.03	6.4	116
Yemen	22	67	3	0.05	0.4	18

Source: *R & D Systems in the Arab States: Development of S&T Indicators* and *The Higher Education System in the Arab States: Development of S&T Indicators*, report prepared for UNESCO by Subhi Qasem (UNESCO Cairo Office, 1995).

Note: FTE = full-time equivalent.

* 1992 data.

a/ No data were available on the occupied territories.

b/ Including autonomous and ministry-governed institutes and universities excluding the industry sector.

c/ Holders of Ph.D. and M.Sc. degrees.

d/ Including holders of B.Sc. and other degrees.

TABLE B.2. NUMBER OF HOLDERS OF Ph.D., M.Sc., B.Sc. AND OTHER DEGREES ENGAGED IN RESEARCH AND DEVELOPMENT*

Country[a/]	Total[b/]	Ph.D. and M.Sc. degree holders	B.Sc. and other degree holders
		Total	Total
Egypt	27499	7546	19953
Jordan	1053	331	722
Kuwait	878	323	555
Lebanon	417	190	227
Qatar	74	32	42
Bahrain	105	51	54
Iraq	2011	1054	957
Oman	190	41	149
Saudi Arabia	1878	765	1113
Syrian Arab Republic	1840	330	1510
United Arab Emirates	179	93	86
Yemen	1043	260	783

Source: *R & D Systems in the Arab States: Development of S&T Indicators* and *The Higher Education System in the Arab States: Development of S&T Indicators*, report prepared for UNESCO by Subhi Qasem (UNESCO Cairo Office, 1995).

* 1992 data.
a/ No data were available on the occupied territories.
b/ Including autonomous and ministry-governed institutes and universities excluding the industry sector.

TABLE B.3. R AND D EXPENDITURE BY SOURCE OF FUNDS*
(Millions of US dollars)

Country[a/]	Total	Source of funds		
		Autonomous and ministry governed	University	Private sector
Egypt	143.8	113.2	30.6	-
Jordan	13.5	7.9	4	1.6
Kuwait	47.2	38.6	8.6	-
Lebanon	5.2	2.3	2.9	-
Qatar	4.3	1.6	2.7	-
Bahrain	1.94	0.95	0.99	-
Iraq	33.1	18.9	14.2	-
Oman	5.9	4.5	1.4	-
Saudi Arabia	131.1	83.6	47.5	-
Syrian Arab Republic	13.9	11.1	2.8	-
United Arab Emirates	10.8	5	5.8	-
Yemen	4.7	3.8	0.9	-

Source: *R & D Systems in the Arab States: Development of S&T Indicators* and *The Higher Education System in the Arab States: Development of S&T Indicators*, report prepared for UNESCO by Subhi Qasem (UNESCO Cairo Office, 1995).

* 1992 data.
a/ No data were available on the occupied territories.

TABLE B.4. NUMBER OF FTE RESEARCHERS (HOLDERS OF Ph.D. AND M.Sc. DEGREES) ENGAGED IN RESEARCH AND DEVELOPMENT BY THEIR AREA OF RESEARCH*

Country[a/]	Total[b/]	Area of research					
		Agricultural prod. and allied resources	Health, nutrition and biotech.	Industry	Engineering and basic sciences	Energy including petroleum	Social sciences and humanities
Egypt	7546	3675	1422	443	805	785	416
Jordan	331	91	57	53	58	16	56
Kuwait	323	74	34	19	121	41	34
Lebanon	190	60	39	16	38	11	26
Qatar	32	6	2	0	9	3	12
Bahrain	51	9	9	0	11	5	17
Iraq	1054	569	103	35	119	43	185
Oman	41	21	9	0	4	4	3
Saudi Arabia	765	137	99	50	208	118	153
Syrian Arab Republic	330	132	19	43	79	20	37
United Arab Emirates	93	65	10	0	6	0	12
Yemen	260	175	16	0	15	0	54

Source: *R & D Systems in the Arab States: Development of S&T Indicators* and *The Higher Education System in the Arab States: Development of S&T Indicators*, report prepared for UNESCO by Subhi Qasem (UNESCO Cairo Office, 1995).

* 1992 data.

a/ No data were available on the occupied territories.

b/ Including autonomous and ministry-governed institutes and universities excluding the industry sector.

TABLE C.1. SECTORAL AND COUNTRY DISTRIBUTION OF CONTRACTS DURING THE PERIOD 1992-1995 FOR THE ESCWA MEMBERS

(Millions of US dollars and percentages of country/area totals)

Country/area	Agriculture & fishing	Defence	Industry	Infra-structure	Services	Tourism	Transport	Total
Bahrain	1.30	---	118.81	297.68	256.56	10.70	1 576.41	2 261.46
	0.06		5.25	13.16	11.34	0.47	69.71	100.00
Egypt	118.47	258.88	1 480.85	2 319.07	277.00	98.18	2 453.75	7 006.20
	1.69	3.70	21.14	33.10	3.95	1.40	35.02	100.00
Occupied territories		---	15.00	11.30	49.01	---	76.00	151.31
	0.00		9.91	7.47	32.39		50.23	100.00
Iraq	5.00	---	23.91	1.41		---	0.50	30.82
	16.22		77.58	4.57	0.00		1.62	100.00
Jordan	0.29	---	544.71	586.11	108.66	25.55	724.56	1 989.88
	0.01		27.37	29.45	5.46	1.28	36.41	100.00
Kuwait	10.30	1 359.20	1 445.81	1 725.53	814.95	169.70	1 647.08	7 172.57
	0.14	18.95	20.16	24.06	11.36	2.37	22.96	100.00
Lebanon	---	---	195.54	1 624.27	267.80	325.00	432.62	2 845.23
			6.87	57.09	9.41	11.42	15.21	100.00
Oman	42.50	797.30	437.21	457.10	271.22	6.40	108.50	2 120.23
	2.00	37.60	20.62	21.56	12.79	0.30	5.12	100.00
Qatar	5.30	642.00	1 260.61	1 073.30	147.09	15.90	367.40	3 511.60
	0.15	18.28	35.90	30.56	4.19	0.45	10.46	100.00
Saudi Arabia	115.90	1 236.56	9 531.83	3 718.53	3 069.98	120.50	640.92	18 434.22
	0.63	6.71	51.71	20.17	16.65	0.65	3.48	100.00
Syrian Arab Republic	15.20	---	439.80	1 945.52	---	---	---	2 400.52
	0.63		18.32	81.05				100.00
United Arab Emirates	14.01	440.80	1 891.69	4 712.65	1 115.09	123.80	1 111.13	9 409.17
	0.15	4.68	20.10	50.09	11.85	1.32	11.81	100.00
Yemen	23.30	---	518.60	143.43	45.38	60.05	---	790.76
	2.95		65.58	18.14	5.74	7.59		100.00
Sector totals	351.57	4 734.74	17 904.37	18 615.90	6 422.74	955.78	9 138.87	58 123.97

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published by the *Middle East Economic Digest* on contracts concluded in the region during the years 1992-1995.

Note: Keywords describing the contents of these sectors are presented in annex table C.3.

TABLE C.2. DISTRIBUTION OF CONTRACTS CONCLUDED DURING THE PERIOD 1992-1995 BY ESCWA MEMBER COUNTRIES/AREAS OVER INDUSTRY CATEGORIES

(Millions of US dollars)

Industry category	Bahrain	Egypt	Occupied territories	Iraq	Jordan	Kuwait	Lebanon	Oman	Qatar	Saudi Arabia	Syrian Arab Republic	United Arab Emirates	Yemen	Total
Not specified		31.10		0.41		0.75		15.30	0.20	0.40		25.00		73.161
Automotive										8.00				8
Bitumen		14.40												14.4
Bottling & canning						18.00				2.00		47.40		67.4
Cement & glass		145.00				0.56	195.00	103.00	127.00	1391.70		54.07		2 016.331
Chemical	19.23	215.20			308.39				5.00	21.00	22.50			591.32
Construction										24.00				24
Control systems										16.00				16
Electricals & electronics								0.58		266.60	23.00			290.183
Emission control												0.95		0.952
Fertilizers					60.00				1.61	28.20				89.805
Food		20.60	15.00		6.12	3.90		20.80	22.50	149.10	159.00	40.69		437.71
Handicrafts					0.40									0.4
Industrial estate								15.00						15
Leather	0.54				1.30									1.836
Marine										6.00				6
Metallurgical	33.95	798.25			22.40		0.44	8.12	50.30	208.85				1 122.319
Mining					4.70							5.00		9.7
New plant					4.00				4.10	47.70				55.8
Oil & gas	0.50	117.10			95.40	749.20		274.40	746.80	4740.63	234.80	1655.82	516.00	9 130.653
Paper	6.10													6.1
Petrochemical		9.30			3.00	87.00			303.10	932.38		13.10	2.60	1 350.48
Pharmaceutical										26.70				26.7
Power	58.50				39.00	218.00						27.80		343.3
Reclaimer bridge												0.95		0.954
Refining						358.10				485.40	0.50	12.90		856.9
Rubber		10.90												10.90
Sanitary ware										40.00				40
Textiles				23.50			0.10					8.00		31.6
Utilities		109.00								2.70				111.7
Vegetable oil										6.87				6.87
Waste management										2.20				2.2
Water		10.00				10.30				1 125.40				1 145.7
Total	118.81	1 480.85	15.00	23.91	544.71	1 445.81	195.54	437.21	1 260.61	9 531.83	439.80	1 891.69	518.60	17 904.37

Source: Unpublished results of a survey conducted by the ESCWA secretariat on the basis of information published by the *Middle East Economic Digest* on contracts concluded in the region during the years 1992-1995.

Note: Keywords describing the contents of these sectors are presented in annex table C.3.

TABLE C.3. KEYWORDS DESCRIBING CONTENTS OF SECTORS

- **Agriculture and fishing:**

  Animal husbandry, Fishing, Fishing Harbours, Food, Irrigation and Land reclamation.

- **Industry:**

  Automotives, Bitumen, Bottling and Canning, Cement and Glass, Chemical, Coal, Construction, Control Systems, Electrical/Electronic, Emission Control, Fertilizers, Food, Handicrafts, Industrial Estates, Leather, Metallurgical, Mining, New Plants, Oil and Gas, Paper, Petrochemical, Pharmaceutical, Power, Refining, Rubber, Sanitary Ware, Spill Control, Textiles, Utilities, Vegetable Oil, Waste Management and Water.

- **Tourism:**

  Advertising, Aviation, Archaeological Sites, Beach, City Centre, Hotels, Sports and Recreation, Theatre, Tourist Villages and Utilities.

- **Infrastructure:**

  Administration, Urban, City Centre, Electrical/Electronic, Housing and Offices, Land, Natural Resources, Oil and Gas, Petrochemical, Ports, Power, Pumping, Sports and Recreation, Telecommunications, Utilities and Water.

- **Transport:**

  Aircraft, Airports and Air Transport, Automotives, Bus Shelters, Land, Marine, Oil and Gas, Ports, Railways, Roads and Shipping.

- **Services:**

  Administration, Archaeological Sites, Banking, City Centre, Clothing, Control Systems, Education, Environment, Exhibition Facilities, Export/Import, Finance, Food, Housing and Offices, Investment, Libraries, Malls, Media, Medical, Real Estate, Places of Worship, Safety Equipment, Social Centres, Sports and Recreation, Standards Facilities, Stock Exchange, Telecommunications, Towers, Trade, Training and Utilities.

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