

**In Cooperation with
UNESCO Division of Science Policy and Analysis
and
UNESCO Regional Office for Science and Technology in Latin America and Caribbean**

**SCIENCE & TECHNOLOGY STATISTICS AND INDICATORS
IN DEVELOPING COUNTRIES: PERSPECTIVES AND CHALLENGES**

Working Document

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I. Introduction

1. The World Conference on Science held in Budapest in 1999 placed emphasis on the necessity for countries to have access to reliable and policy-relevant statistics on science and technology (S&T): "Government should promote the further development or setting up of national statistical services capable of providing sound data."¹ It is an appropriate time to make a new effort to assess worldwide progress in S&T statistics, to build an understanding of the difficulties that countries are presently encountering in collecting and using such data, and to identify emerging information needs. It is against this background, that the UNESCO Institute for Statistics (UIS), which was established at the General Conference in 1999, is initiating a fundamental international review of policy information needs and statistical activities in the fields of science and technology. The aim is, on the one hand, to identify priorities as well as strategies for improving the relevance, availability and quality of S&T statistics in countries around the world, and, on the other hand, to help define a new UNESCO statistical programme in the field of S&T. The ultimate goal is to revitalize efforts at both the international and national levels to build S&T statistical systems that are highly responsive to policy information needs, and to strengthen the UIS's role in stimulating and facilitating this revitalization process, especially through its activities in standard setting and in the gathering of cross-nationally harmonised data.
2. The review shall be carried out in three stages:
 - i. involvement of international experts to advise on key issues and questions with regard to policy information needs and possible areas of development of science and technology statistics and indicators;
 - ii. consultation with the Member States, relevant institutions and specialists;
 - iii. preparation of a strategy document defining the UIS's priorities and programme for the development of international statistics and indicators in science and technology
3. This document has been prepared to assist with the first phase. It attempts to take stock of some of the current policy concerns, to review existing S&T data areas, systems and indicators, and to propose some questions to stimulate the debate with regard to how best to conduct the review
4. Following this introduction, the second part of this document summarises a number of potentially key science policy developments as a first attempt to produce material which can be circulated to countries to solicit their comments and their ideas for additions to the policy information needs. The views of experts on this tentative list of science policy issues and their articulation into S&T indicators will be very valuable.
5. The third part of this document briefly outlines the 'state of the art' in S&T statistics and indicators in both developing as well as developed countries, so as to help in gauging the extent to which those statistics and indicators currently available respond to identified policy

- information needs. The document ends with a discussion about possible areas and systems of S&T statistics and indicators focusing especially on developing countries, aimed at identifying salient questions to be addressed to the Member States and relevant institutions.
6. The discussions conducted on the basis of this working document will help in the preparation of improved material for use in consultation with the Member States.

II. Science and technology policy: main issues

7. Over the last twenty years, policies on science and technology have evolved considerably. It can be argued that economic competitiveness and globalisation call for tighter management on the part of institutions and for the prioritisation of scientific and technological activities. The redefinition of the role of the State in many countries combined with shrinking public sector budgets affects many scientific institutions and has led to increasing emphasis on private funding. Additionally, the technological gap between countries, in particular between countries of North and South, is believed to be steadily widening.
8. Dazzled by the phenomena derived from the big science and pressed by the urgency of economic growth, more and more developing countries have felt the need to define science policy and to develop strategic S&T development plans during the past decades. Awareness is also spreading of the need to pay attention to technology management and innovation issues. However, these efforts have been limited to certain segments of society, have been poorly rooted in the productive sector, and have had a limited receptivity in the political systems.
9. The dynamics of the global economy, the challenges of regionalisation and integration, and the need to develop societies which can adapt well to changing circumstances which imply greater risks than in the past, may have produced a renewed interest in S&T development strategies and policies. Such strategies need to incorporate new approaches that result, on the one hand, from the new paradigms that guide scientific and technological policies in the world (for example, the need to respond to demand and emphasis on stimulating innovation processes) and on the other hand, from the special characteristics of developing countries. As problems such as production competitiveness become the cornerstone for the development of local S&T capacities, many developing countries feel the need to formulate science and technology policies which are interlinked with the rest of public policies to a greater extent than in the past. Consolidation of basic scientific and technological capabilities is being given increasing emphasis, though there may be great heterogeneity in the ways these countries achieve this.
10. It is thought to be the case that in many developing countries, the State has practically abandoned the pretence of relative S&T autonomy in terms of an endogenous scientific and technological capacity, and has replaced it with a modernization policy that seeks to tap into S&T resources available both in-country and from abroad. Frequently at a purely formal level an 'innovation policy' is postulated, although the institutions responsible for implementing such policies (science and technology councils, industry departments) in general do not have the political weight nor the capacities, and above all, do not have the resources which would be required. In some countries there has been a trend towards the articulation or emergence of a national system of innovation. This can be a network of institutions, resources, interactions and relationships, political mechanisms and instruments, and scientific and technological activities that define, promote, articulate and encourage technological innovation and diffusion processes in society (generation, import, adaptation and diffusion of technologies). There is however little empirical evidence of the existence and operation of such systems of innovation in developing countries (and probably not in many developed countries).
11. In the light of such changes, S&T policies have had to respond to new concerns which are being raised by a widening range of stakeholders from different segments of society notably

the business world, researchers from the public and private sectors, and the population as a whole. Today, a variety of issues influence public policies in science and technology, and these could include:

- Quantity and quality of human resources for science and technology
- Science education and training especially at secondary and tertiary level including teacher training
- Access to S&T knowhow and barriers to knowledge transfer
- Importance of leading edge technology to productivity and competitiveness
- Impact of new information and communication technology on S&T development
- Social understanding and popularisation of science and technology
- Interrelationships between science, technology and gender
- Adequacy of institutional capacities for S&T
- Effectiveness of S&T instruments and mechanisms and development strategies
- Decrease in public budgets and funding for S&T
- Prioritisation of government investments in key technologies and sectors
- R&D infrastructure and pressures to increase its socio-economic relevancy
- Evaluation of R&D programmes and projects
- Linkages between universities and industries, and commercialisation of public research findings
- S&T brain-drain
- Balance between civilian and defence R&D

What policy issues are missing from this list ? The views of experts on the prioritisation of these policy issues in science and technology will be welcomed.

12. It is evident that these issues impose upon countries the need to formulate science and technology policies that are more closely linked to the rest of public policies than they have been in the past: competitiveness transcends the scope of economy and becomes the cornerstone for the development of capabilities; solutions to social problems necessitate an integrated view involving many actors and fields of public affairs. Decision makers now require more and better information that enable them to assess the results and the effectiveness of policies that have been adopted. This may include indicators which depict existing institutional capacities and resources, level of S&T activities, the processes involved, results obtained, and remaining technological gaps.
13. The time is ripe to make a new inventory of current S&T policy needs, and to try to identify emerging issues. This is an essential step before we can examine the match between science policy priorities and existing information, so as to determine priority areas of S&T statistics and indicators to be developed in the future. The UIS proposes to adopt a policy-driven approach in which identified policy priorities will be translated into information needs and indicators which in turn will lead to conceptual and methodological work. The latter will incorporate statistical measurements and related operational issues in the collection and analysis of data and the production of relevant, reliable and meaningful information and indicators. It will be essential to ensure that the data areas which are chosen can be meaningfully measured, and it will also be necessary to ensure that effective mechanisms are put in place to deliver the information in an easy-to-understand form to policy makers. To the extent possible, national specificities in terms of science policy priorities and monitoring capacities will be taken into account when developing a new international S&T statistics and indicator system. It is critical that international data collection does not distort the national priorities. So where appropriate, countries with similar policy concerns and statistical capabilities may work together on common sub-sets of science indicators.

III State of the art in S&T statistics and indicators

14. In terms of existing S&T statistics and indicators, for more than 40 years, persistent efforts have been made by UNESCO, OECD and EUROSTAT to promote the systematic measurement of S&T and to collect and disseminate cross-national statistics and indicators on S&T. Today, cross-national statistics are available for many industrialized countries but for fewer developing countries with respect to human and financial resources in R&D, innovations, citations, patents, international trade in high-technology products, balance of technological payment, etc.(see table 1 on the next page). These statistics have been collected in the countries concerned based on clearly-defined international concepts and methodologies that have been embodied in methodological documents including the Frascati Manual², Oslo Manual³, and Canberra Manual⁴.
15. During this period and based on the advice of international expert groups, UNESCO has concentrated its work in identifying and developing common data areas which respond to the policy needs of both developed and developing countries, including the former socialist countries. Such work has focussed on developing ways to measure the S&T capacity of each country⁵, including institutional capacities and infrastructure, the level of S&T activities, as well as the scientific and technological capabilities of the population as measured by the stock of scientists, engineers and technicians.
16. Adoption by the Member States of the 1978 Recommendation on the International Standardization of Statistics on Science and Technology⁶ was instrumental in orienting UNESCO's programme in science statistics in the 1980s and 1990s, which focussed on R&D statistics and other S&T activities in particular scientific and technological information and documentation (STID)⁷ and scientific and technological education and training (STET)⁸, for which conceptual and methodological manuals and guides have been widely disseminated to the Member States to help them collect these statistics.
17. By following a systems approach of input-process-output-impact, traditional S&T input indicators are based on the measurement of the expenditure incurred in and the personnel devoted to R&D activities or to STA (scientific and technological activities). These macro indicators reflect in their design the 'linear-sequential model' that conceives the process of production and application of knowledge as a series of successive and necessary stages starting from basic research up to innovation, passing through applied research and experimental development. It frequently becomes a regulation model for the countries (mainly developing ones), which try to adapt their policies accordingly, but it masks the specific characteristics of scientific research and technological development processes. The linear-sequential model is seriously questioned by scholars and institutions alike, and that a consequence of

Table 1.
S&T indicators currently available

Indicators	Advantages	Disadvantages	Available since
<p>RESEARCH AND DEVELOPMENT (R&D)</p> <p>R&D is measured according to allocated expenditures and human resources input (Methodological basis: FRASCATI Manual).</p>	<ul style="list-style-type: none"> - Generally applied in a great number of countries - Standardised historical series 	<ul style="list-style-type: none"> - Classifications needing updating (field of science, source of funding, etc). - Variable coverage of sectors depending on national systems - Difficulty in understanding certain concepts (PT, EFT, FT, etc.) - Difficulty in distinguishing R&D activities from other related activities 	<p>1960</p> <p>In OECD and Eurostat member countries; and a number of developing countries</p>
<p>HUMAN RESOURCES in Science and technology</p> <p>Measured in terms of science education and training according to levels and fields.</p> <p>(Methodological basis: CANBERRA Manual)</p>	<ul style="list-style-type: none"> - Based on international classifications recognised by ISCED - Statistics are regularly collected by education systems 	<ul style="list-style-type: none"> - Difficulty in obtaining data regarding on-the-job and continuous training - Difficulty in "measuring" correspondence between people's employment and their training - Difficulty in estimating time occupied in R&D (EFT) and in other S&T activities 	<p>1950</p> <p>In most developed and developing countries</p>
<p>INNOVATION</p> <p>Measurement of all activities</p>	<ul style="list-style-type: none"> - Regular surveys on innovation are conducted in 	<ul style="list-style-type: none"> - Innovation activities can be difficult to measure 	<p>1992</p> <p>In the majority of OECD and</p>

<p>leading to technological innovation</p> <p>(Methodological basis: OSLO Manual).</p>	<p>European countries</p> <ul style="list-style-type: none"> - The Oslo manual underlines standards used to measure innovation 	<ul style="list-style-type: none"> - Concepts are not always clearly understood - Difficult to apply in countries which do not have statistical system on industries and business 	<p>Eurostat member countries</p>
<p>PUBLICATIONS</p> <p>Measurement of the level of production and dissemination of S&T knowledge</p>	<ul style="list-style-type: none"> - Citations are the only indicators for the measurement of the diffusion of scientific knowledge 	<ul style="list-style-type: none"> - There is no reference manual - Coverage of countries is incomplete - The quality of publications is not taken into account - Quotes do not measure the quality of publications 	<p>1970</p> <p>This information is essentially collected by and accessible through some non-governmental institutions</p>
<p>PATENTS</p> <p>Measurement of inventions</p>	<ul style="list-style-type: none"> - The number of patents requested and issued is easily accounted for 	<ul style="list-style-type: none"> - Low percentage of patented inventions - Number of patents does not inform on the importance of inventions - Commercial value of inventions unknown 	<p>1980</p> <p>Three main sources: EPO, USPTO, and JPO</p>
<p>IMPACT</p> <p>Balance of technological payments High technology industries (balance of trade) Dissemination of technologies Scientific culture</p>	<ul style="list-style-type: none"> - Allow us to measure economic impacts 	<ul style="list-style-type: none"> - Are mostly limited to the economy, do not take into account sociocultural and political aspects - Require well developed and transparent accounting systems 	<p>1980</p> <p>OECD, EUROSTAT</p>

this is the search for new indicators (such as innovation indicators). It should be recognized however that input indicators relating to scientific and technological activities in general, and of R&D in particular are the basic information many countries produce so as to locate their relative position as regards science and technology. Although these indicators (particularly those related to finance and human resources) do not measure well the differences between systems, they do constitute a starting point for measuring STA, since the search for new indicators will demand the availability of information referring to parameters such as the allocation of economic, material and personal resources to STA.

18. The application of such input indicators in developing countries faces many conceptual and methodological difficulties. Given that S&T activities are difficult to compare across different country situations, the internal flows of the system reveal different organisational structures which must be studied empirically with a view to defining specific conventions and common methodological approaches. In addition, the structure of employment and the institutional profiles in most developing countries make the identification of actors in S&T activities difficult. To illustrate the point, UNESCO's experience shows that currently, statistics on human and financial resources devoted to R&D are available for only about seventy countries in the world, including some 30 developing countries, and the available data are of very variable quality. As regards methodological difficulties, a consensus on the need to develop common methodologies that guarantees the comparability of information is becoming more and more necessary.
19. S&T output indicators represent a rather more recent endeavour. Bibliometric indicators are one of the common tools for measuring scientific research output. Similarly patent indicators are generally used for measuring technological research output. As to bibliometric indicators, the Science Citation Index, and the Social Science Citation Index elaborated by the Institute for Scientific Information (ISI) of Philadelphia, are the most widely used databases. Their records are used to build indicators on the number of publications, quotations frequency and scientific impact. Other bibliometric bases, such as the French PASCAL, incorporate a wide range of publications, which in some cases complement the ones registered by the ISI, but they present some operative difficulties when used in the elaboration of bibliometric indicators.
20. The utility of bibliometric indicators based on these sources is questionable when used to measure scientific production in developing countries, since the majority of the renowned specialized magazines are published in industrialized countries and their subject orientation, criteria, language, and informal access circuits usually place researchers in the South at a disadvantage. Scientific production in developing countries does not necessarily follow the same path towards publication as it does in other countries in the world. Not every discipline in developing countries (notably in the social sciences) publishes results and scientific communications in magazines registered by the ISI. Nor have the scientific magazines in developing countries the profile to be included in the international databases since these are often based on large circulation figures and since they often do not confirm to the editorial guidelines required. In spite of these difficulties, these indicators are not easily replaceable for measuring scientific outputs. The more consolidated or "internationalized" areas of science in some developing countries are gradually accepting the use of bibliometric indicators. But even taking into account the above limitations, the relative insignificance of the scientific production of developing countries in "mainstream" publications should not be overlooked.
21. Patent indicators are used because they are easily obtained both nationally and from international databases. However, they are frequently criticized because they do not necessarily reflect real innovation production capacities, since not every innovation is patented nor every patent applied (thus constituting an innovation). Besides, in view of the different legislations on intellectual property in developing countries, registrations cannot be

compared on an international basis. In addition, historical series on a national level register significant variations, which can only be explained by amendments to the legislation not directly related to scientific and technological capabilities.

22. Over the last two decades, industrialized countries have increasingly adopted neo-schumpeterian approaches which focus on industrial innovation processes as the basis for competitiveness and economic growth. Policies that promote innovation have been gradually replacing the old policies in science and technology. At the same time, S&T development approaches based on economic demands have been replacing approaches based purely on knowledge generation. For these reasons, industrialized countries have been conducting analytical and empirical studies together with theoretical developments of technological innovation processes, and produced indicators that gave birth to the Oslo Manual in 1992 (and its revision in 1996). As might have been expected, local production processes in the developing countries do not necessarily coincide with the basic characterization arising from the observation of these processes in industrialized countries. However, some developing countries have made efforts to review and adapt these methodologies to the characteristics of their own innovation processes.
23. Parallel to the approach of systems of innovation the idea of the knowledge society (or the knowledge-based economy) has emerged. Recent approaches place special emphasis on human resources. In order to measure human resource capacities the OECD has developed the Canberra Manual which was published in 1995. The manual takes into account a larger group than researchers, encompassing a variety of professional and technical personnel engaged in S&T activities.
24. The outline above of what has been collected in the past serves to highlight the achievements as well as some of the limitations and gaps in current S&T statistics. It can help us to seek improvements especially with regard to the wide range of emerging policy concerns including the ones identified in the previous section. For example, to date practically no cross-national statistics exist to describe the S&T capabilities of national populations; the degree of access to S&T knowhow and derived benefits; the quality and effectiveness of science education; the effects of S&T brain-drain; the balance between civilian and defence R&D; circulation of indigenous S&T knowledge; just to name a few examples.
25. In most developing countries scientific and technological activities have not arisen from an organic relationship with economic and social processes and the general cultural environment. Thus, a major goal of science policies for the future must be to overcome such divisions, and to become 'connected'. This means that systems of science and technology statistics and indicators used for monitoring policies must be capable of indicating progress, problems and issues in S&T development in relation to socio-economic development. Given the importance of distinguishing between optimism and what can be achieved, any effort to revitalize the use of science and technology statistics and indicators must from the beginning take into account this lack of articulation, and other distortions and limitations. These might include issues as diverse as the weak links between R&D and the higher education system on the one hand, and with the productive sector on the other hand, and the decreasing academic excellence levels which are apparent in many societies plus the poor availability of reliable information.
26. Although it seems a generally acknowledged fact that the spread of science and technology propels economic and social development, several questions should be asked:
 - How best can we measure the level of scientific and technological capacity, activities and potential in developing countries?
 - Under what conceptual and methodological assumptions should the measurement be made so that they can be reliably used as policy and management instruments?
 - How should the contribution of scientific and technological activities to economic and social development and to productivity gain be measured?

- How much money should be invested in science and technology and basically, in what type of scientific and technological activities?
27. The question on how to gauge the scientific and technological capacity of countries to respond to social and economic demand, and how to evaluate its possible contribution to the fulfilment of society's basic and productive needs, is always present.

IV. Systems of S&T statistics and indicators: future challenges

28. Numerous indicators are used today around the world to measure different dimensions of science and technology. It can be argued that S&T indicators should above all address priority policy concerns by meaningfully and reliably explaining salient aspects of S&T development in a given country. Such indicators would enable unbiased monitoring of scientific and technological capacities and activities, whether at the level of input, process, output or impact.
29. At the international level, measurement methodologies governing S&T statistics and indicators offer a global perspective but more importantly serve as input to within-country policy-making and management of science through permitting comparisons to be made with the scientific and technological capacities of other countries. As with many instruments used in the design of the institutional system of science and technology, there is a risk of applying models appropriate only to particular first-world realities. There is a growing need for standard methodologies that aim at simultaneously establishing mutually compatible national and international systems of science and technology statistics and indicators. The set of statistics and indicators covered by such methodologies should be based on common concepts, standard structure, and a uniform design in keeping with international norms. At present, many of these methodologies have been designed according to the scientific and technological problems of industrialized countries, and often do not respond to policy concerns in the developing countries.
30. It has been argued that indicators that are only based on the experience of industrialized countries can lead to counter-productive science policy and management practices in poorer countries. They can confound efforts in the developing countries to determine data collection methodologies that are appropriate to the national needs in respect of the definition of global or sectoral science and technology objectives, the determination of priority scientific and technological activities, the promotion of technology innovation processes, or the definition of the most important areas for training scientific and technical personnel and building S&T capacity.
31. There have been proposals that the developing countries should extend beyond conventional input indicators (research centers, researchers, training of scientific and technical staff, financial resources) and products (published articles, index of quotations, licenses, patents, plans and specifications, etc.), by including a systematic measurement of their scientific and technological capacities. To that end, they should develop paradigms that reflect, as specifically as possible, the nature, the distinctive elements, the dynamics and the magnitude of local scientific and technological activities. Areas of measurement and analysis ought to reflect the main issues of concern, highlighting critical gaps in scientific and technological development, so as to contribute in an effective way to the analysis of national science and technology problems, to decision making and to the allocation of resources. This may lead to an appreciation that international standardization is both a consequence as well as a prerequisite for sound national measurement of scientific and technological activities.

IV.1 Dimensions to be measured

32. Depending on national conditions, concerns and needs, S&T activities can be measured across different policy dimensions and activity areas. The question arises, then, as to how best to develop a viable strategy to measure them in accordance with policy priorities.
33. Based on the perceived policy concerns identified in Section II, a number of indicator areas can be proposed for the development of international measurement. Which of the following areas have more importance and can be given higher priority? Are there other areas? What are they?
- *Education, training and human resources in S&T*
Education remains a main avenue for building human resources in S&T in both developed and developing countries. Science and technology education are organized in formal schools and colleges, but can also take place in informal settings like the workplace or through the mass media and popularisation activities of scientific bodies, not to mention in daily life. Because women continue to be under-represented among students and graduates in science and technology, there is a need to systematically monitor gender biases in human resources in S&T. Are current statistics for higher education adequately measuring individuals' qualifications and the stock of human resources in S&T (according to field of education)? The same question may be asked of employment statistics (by occupations)? Are the current educational and occupational classifications adapted to the needs of S&T decision makers? How can one measure S&T education and training that take place in informal settings? What information is needed to measure the migration of S&T human resources (the brain drain)?
 - *Scientific culture*
One of the essential conditions for deriving full benefits from scientific and technological development is a positive scientific culture amongst the population in general, and decision-makers in particular. Societies not only need citizens who can fully participate in applying and generating S&T knowledge and products, but also a majority of the population who are capable of understanding the scientific principles and laws governing nature and the environment so as to conscientiously contribute to sustaining them. Equally important is the need for managers who can invest in S&T in judicious ways. There have been attempts to gauge the level of S&T knowledge among persons of different gender, age-group and other social, economic, ethnic, linguistic characteristics, through the use of sample surveys and test measurement. Can scientific culture be measured? If yes, how best can it be measured? Are such measures pertinent in developing countries? If not, how can we develop ways to indirectly gauge scientific culture?
 - *R&D Capacity*
R&D reflects a country's capacity to generate S&T knowledge, hence is a key area as far as the measurement of S&T is concerned. R&D statistics have concentrated on input factors such as financial and human resources and physical infrastructures. It is recognized that the networking of people and institutions, nationally and internationally, is an important element of success in R&D. Better measurement of the outputs and benefits of R&D have yet to be developed. Are the standard indicators on R&D (expenditure and research personnel) deemed essential in developing countries? Can we consider it adequate as a measurement of scientific and technological activities which include more than R&D? What other kind of S&T activities should be and can realistically be measured? Are the following R&D dimensions subject to common definitions which can be applied across different countries?
 - fundamental research/applied research/experimental development;
 - sectors: universities, governments, business, non-profit organisations;

- classifications: according to fields of science; industries; socio-economic objectives; sources of funds; FT/PT/FTE, etc.
- *Innovation*

In modern economies, innovation is a decisive factor of economic growth. In developed countries, it is the business sector that performs the major part of innovations. The business sector as a whole, and innovation activities in particular, are less organized in developing countries, and it can be difficult to collect data from private enterprises.

Given the low level of innovative activities in the business sector in developing countries and the difficulties of collecting data on this sector, is it realistic to conduct surveys on innovation in developing countries? On what conditions can this be done? Would it be desirable to combine R&D and innovation surveys?
- *Output*

In the last twenty years or so, governments have required evaluative mechanisms of research activities. Various indicators have thus been used over recent years to measure the quantity of output of scientific and technological activities, notably the number of publications and number of patents.

Are these indicators relevant as a measure of research output from developing countries? Are they biased towards so-called advanced scientific and technological systems? What specific output should we then measure at the international level, and how should this be done?
- *Knowledge and technology transfer*

Alongside the endogenous generation of S&T knowledge, international transfer and cross-fertilization of technologies and knowhow have become essential to the S&T development of any country. The economic success of today's greatest power is due to the free exchange of scientific ideas and technological advances that occurred since the last century. It seems therefore important to measure developing countries' level of access to, absorption, adaptation and application of S&T knowledge from abroad.

What is the significance of the measurement of knowledge transferred to (and from) developing countries? Do such statistics allow for the measurement of both the movement as well as the capacity to absorb knowledge? Is the balance of technological payments sufficient to realistically illustrate the current situation? What intangible exchanges should be measured? Are statistics on the various forms of scientific collaboration useful to this end? What other indicators can be developed?
- *Diffusion and use of technologies*

Economic growth depends more and more on the continuous supply and use of technologies, wherever they are produced. There is still a large gap, however, between developed and developing countries as regard the diffusion and use of certain technologies, among them information and communication technologies (ICT).

How can the diffusion and use of new technologies be measured? What are the underlying concepts and mechanisms for collecting data and producing indicators on access to and transfer and utilization of technologies?
- *Impact of science on development*

Governments fund R&D for the potential benefits from science and technology to development (economic, social, etc.). To date, however, there are few impact indicators, except for some S&T economic impact indicators such as the balance of technological payment, dissemination of information and communications technologies.

Would it be desirable to define other impact indicators? How can social impacts, organisational impacts, etc. of science and technology be measured?

IV.2 Conditions for reliable measurements

34. S&T activities are diversified and can take place in different settings and sectors. A great deal of emphasis is given to the reliability and meaningfulness of the measurement. In developing countries, a very first task prior to defining science and technology indicators is a thorough analysis of existing capacities and conditions for organizing reliable measurement. Naturally, this implies the necessary reformulation of concepts and ideas about scientific research and technological development in developing countries, which would enable the identification of relevant measurement variables, methodologies and data collection channels.

- *Identification of needs*

In order to be relevant S&T measurement should be preceded by a full assessment of the real needs of the Member States with respect to information that can contribute to the development of their science policies, and facilitate implementation, management and evaluation of S&T activities. Have the Member States already taken stock of these information needs? What are the main findings?

- *Statistical organisations*

It will be vital to have a clear picture within each country of the statistical system and responsibilities. For example it will be important to know whether the government currently has a centralised statistical organisation responsible for the collection and dissemination of S&T statistics? If not, which organisations will need to be involved in data collection? Have they improved their S&T statistical systems recently? What importance is given to S&T statistics within these organisations? Are surveys conducted on S&T? What type of survey?

- *Financial and human resources*

What resources - financial and human - are needed by the countries to systematically and reliably measure science and technology? What assistance could UNESCO and its partners provide: training of qualified staff ? networking of experts and/or statistical offices ? sharing of information ? strengthening of national capabilities? How can countries be made aware of the importance of information for science and technology policies?

- *Methodological tools*

Clear conceptual and methodological guidance will be needed to promote the systematic monitoring of S&T activities in the developing countries. Are the manuals and methodological guides (OECD, UNESCO) presently available adapted to the needs of developing countries? How could they be updated? Should new ones be designed, and if so, on what basis? How best can they be prepared ?

V. Where do we go from here ?

35. The main purpose of this initial working document, as explained in the Introduction, is to generate reflection and suggestions among the invited experts regarding how best the UNESCO Institute for Statistics should go about organizing the consultation of Member States and relevant institutions and specialists during the second stage of the S&T review in order to identify priority policy issues as well as measurement areas, methodologies and mechanisms that can be put in place to revitalize the collection and dissemination of relevant and reliable statistics and indicators on science and technology at both the national and international levels.

36. During the meeting in Rio de Janeiro and the weeks preceding it, the experts are invited to offer comments and suggestions with respect to the following:
1. Key policy issues and priorities in science and technology;
 2. Existing data gaps, problems and solutions;
 3. Areas of S&T activities for which reliable and meaningful measurement can be developed in the future; and the implications;
 4. How to effectively generate feedback and ideas from the Member States and relevant institutions and specialists ?
 5. Which are the salient questions that can be addressed to them ?
 6. How should UNESCO go about making use of the feedback in defining its programme priorities and strategies ?
 7. Other related issues and ideas
37. It is expected that the Rio meeting shall help to define appropriate ways and means to move forward to the consultation stage from May to July 2002 during which the UIS shall gather feedback from the Member States and institutions. The results of the consultation shall be summarized and conveyed to the experts for further advice in translating them into programme priorities and strategies.
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¹ 'Declaration on science and the use of scientific knowledge'. World Science Conference, Budapest, 1999.

² OECD : The Measurement of Scientific and Technical Activities: Standard Practice for Surveys of Research and Experimental Development - Frascati Manual 1993

³ OECD : Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (Oslo Manual) 1996

⁴ OECD : Human Resources in Science & Technology (Canberra Manual) OCDE/GD(95)77

⁵ UNESCO : Manual for Surveying National Scientific and Technological Potential, NS/SPS/15, 1970

⁶ UNESCO : Recommendation Concerning the International Standardization of Statistics on Science and Technology 1978

⁷ UNESCO : Guide to Statistics on Scientific and Technological Information and Documentation (STID), ST-84/WS/18. 1984

⁸ UNESCO : Proposal for a Methodology of Data Collection on Scientific and Technological Education and Training at the Third Level, CSR-S-15.