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GENDER INDICATORS IN SCIENCE, ENGINEERING *and* TECHNOLOGY

An Information Toolkit

Sophia Huyer
and
Gunnar Westholm

Science and Technology for Development series
UNESCO Publishing

Gender Indicators in Science, Engineering and Technology

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Preface

One of the major issues facing science, engineering and technology (SET) around the world today relates to the decline of young people, especially women, enrolling in these subjects and entering careers in these fields. This will have tremendous consequences for capacity in science and engineering, particularly in developing countries – where SET applications are vital in social and economic development and in addressing the Millennium Development Goals (MDGs), especially poverty reduction and sustainable development. Capacity in SET is further weakened by brain drain to developed countries.

These issues of capacity and the application of SET to development relate closely to considerations of diversity, access, equity, participation and career development for women in science and engineering. Women are under-represented in all areas of engineering, mathematics, physics and chemistry in most countries around the world. We need to get more women and under-represented groups into SET to promote social and economic development. The situation at the tertiary and professional levels reflects the decline in young people's, especially women's, interest in SET education at primary and secondary school. Children turn away from science and technology (S&T) in the later primary and early years of secondary education – that is where the problem begins.

Indicators and information are required in many countries to help understand and address this situation of declining interest in and entry into science and engineering, and the consequences thereof for capacity and application of SET for social and economic development. We need data and information for evidence-based analysis and understanding of the situation, and for policy-making and planning to address the problem. The situation is compounded in developing countries by the shortage of statistics and indicators on science and engineering.

The production of this UNESCO toolkit on gender indicators in SET is therefore a welcome, timely and indeed overdue contribution to this field. Calls for greater information on and action towards women and gender issues in science and engineering have been made at UNESCO General Conferences for over twenty years, and were a priority of the *Framework for Action* of the World Conference on Science in 1999. UNESCO commissioned the production of this volume to address these calls. The toolkit introduces the subject, discusses the need for gender indicators in SET to counter the 'leaky pipeline' of women into and within science and engineering, surveys the measurement of people and activities in SET, and provides case studies of the collection and analysis of gender-disaggregated data.

The authors, Sophia Huyer and Gunnar Westholm, are specialists on gender issues and indicators in SET, and UNESCO is proud to have been involved in the production of the first publication focusing on this field. We look forward to the contribution that this toolkit on gender indicators in SET will make to the information, policy-making and planning required to address the issues of women and gender in SET.

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Foreword

We live in a time when there is increasing talk of knowledge societies and economies, and of the generation, innovation and globalization of knowledge. There is also greater recognition of the importance of SET in social and economic change and development, promoting poverty reduction, sustainable development and achievement of the other MDGs. At the same time, however, there is increasing concern regarding human, institutional and infrastructure capacity in science and engineering around the world, reflecting an apparent decline of interest, entry and participation of young people, especially women, in many countries. These issues have been emphasized in recent reports from the UN Millennium Project Task Force on Science, Technology and Innovation, the Africa Commission, the InterAcademy Council and the G8.

These opposite trends towards increasing knowledge-based development and decreasing capacity to apply knowledge to development where it is most important – in SET – will have serious implications for developing countries. The situation is compounded by the brain drain of scientists and engineers from developing to developed countries, and away from engineering, as engineers are head-hunted into other sectors, notably banking and finance. Some areas of infrastructure, for example in the energy field, are already reporting constraints due to shortages of engineers. From this perspective, the 'knowledge divide', of which the 'digital divide' is but a part, looks likely to increase, to the detriment of development. We need better understanding in order to address this situation, especially in developing countries, where innovation and application of knowledge in engineering and technology are particularly important.

As change takes place on the input side, in terms of the entry of young people into SET, there is change on the output side, in terms of what engineers and scientists do and how productive they are. As knowledge develops, so do the processes and systems of knowledge production and application. Thus the needs for knowledge and knowledge application also change, and different types and numbers of engineers, scientists and technical support staff are required. This situation, against the backdrop of declining student numbers and shortages of engineers in many countries, highlights the importance of a better understanding of 'numbers and needs' regarding engineers and scientists around the world.

There is a close connection between the reported shortage of engineers and decline of young people going into engineering, and the 'gender dimension' or 'gender divide' regarding the under-representation of women in science and engineering. To address the shortage of engineers in many countries, we need to attract women and under-represented groups into engineering. Although anecdotal evidence is a limited substitute for hard data and attitudinal surveys (both of which are needed), it appears that there are perceptions among young people that engineering education and engineering is 'boring', that engineering degrees are hard work (compared to other courses), that engineers are poorly paid (compared to other careers), and that engineering is part of the problem of pollution and sustainable development, rather than part of the solution.

Young people, especially young women, have been consistently under-represented in all areas of engineering and many areas of science (mathematics, physics and

chemistry) around the world. Efforts to promote participation in many countries increased the enrolment of women in these areas slightly in the 1980s and 1990s, from around 10–15 per cent to 20–25 per cent. Since 2000, however, this progress seems to have declined again, down to 10 per cent in some countries, along with declining enrolment of men in many countries. This decline seems to reflect the perceptions of young people relating to traditional curricula and pedagogy in engineering and science mentioned above, and also to the 'post-bubble' decline in 'high-tech' Information Technology jobs.

Perceptions depend significantly on the relative position of the observer and, even if based on inaccurate information, can lead to real consequences. Many readers here do not need to be convinced that SET are inherently fascinating and rewarding, but there is a clear need to persuade others of this. This requires teaching and learning processes that inspire interest, attract attention and stimulate the imagination and the desire to know, through such approaches as activity-, problem- and project-based learning, and by emphasizing the relevance and application of engineering and science to real-world problems, such as poverty reduction, sustainable development and the MDGs. If the image of science and engineering is partly of machismo and the memorization of formulae, then we must change that image. If that image is the result of science and engineering education, then we must change that education too. Reforming science and engineering education to promote women and diversity will also help to promote the general image of science and engineering.

One of our most important challenges is to examine and better understand this situation so that we can devise effective ways to correct these perceptions if they are wrong, and to address them if they are right. An initial and overriding need is for better data and information for evidence-based advocacy, policy-making, planning, reform and change. Many developing countries have insufficient data to do this, especially data regarding sex-disaggregated statistics and indicators on S&T. Thus the main purpose of this UNESCO toolkit is to provide guidelines, as well as learning and teaching materials, that promote the collection of data on SET to facilitate better advocacy, policy-making, planning, programming and reform of science and engineering. This is also the goal of the UNESCO Institutes for Statistics survey on S&T statistics, which includes a section on gender indicators, and the Orbicom report on women in the information society.

Chapter 1 of the toolkit contains a discussion of gender issues in SET, and the need for data, and introduces the gender dimension to statistics and indicators. The 'leaky pipeline' of women in recruitment, retention and advancement in science and engineering is then explored in Chapter 2, along with activities to understand and address this situation. Guidelines for measuring activities and personnel in SET are presented and discussed in Chapters 3, 4 and 5. Chapter 5 presents several case studies and models that shed light on the collection of sex-disaggregated data. The book concludes with a useful annex of sources of gender-disaggregated data in SET. The title reflects the need to emphasize gender issues in SET, the importance of engineering in the context of development, and the fact that 'technology' is increasingly regarded as IT, at the cost of losing the wider picture and issues relating to technology.

It was a pleasure to have worked with Sophia Huyer and Gunnar Westholm on this project. Sophia focused on the gender dimension, and is the Executive Director of WIGSAT (Women in Global Science and Technology) and Senior Research Advisor to UNCSTD's Gender Advisory Board. Gunnar focused on the indicators side, worked with the OECD on indicators on S&T and R&D, and continues to be active in the field and with NESTI (the OECD group of National Experts for Science and Technology Indicators). I would like to thank Sophia and Gunnar for their friendship and commitment to the production of this toolkit. We hope it will help to address the adage 'no data – no visibility; no visibility – no priority' by supporting and promoting the production of information to raise the visibility and priority of gender issues in SET.

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Acronyms

APEC	Asia Pacific Economic Cooperation
CSW	UN Commission on the Status of Women
EC	European Commission
ECLAC	UN Economic Commission for Latin American and the Caribbean
ECOSOC	Economic and Social Council
EU	European Union
Eurostat	Statistical Office of the European Commission
FAO	Food and Agriculture Organization
FTE	Full-time equivalency
GDOL	Gender division of labour
GDP	Gross domestic product
GER	Gross enrolment ratio
GERD	Gross domestic expenditures on research and development
GESI	Gender-equity-sensitive indicator
GPI	Gender parity index
GSI	Gender-sensitive indicator(s)
GWG	Gender Working Group
HC	Head count
HRST	Human resources devoted to science and technology
ICT	Information and communications technology
ILO	International Labour Office
ISCO	International Standard Classification of Occupations
ISCED	The International Standard Classification of Education
IT	Information technology
MDG	Millennium Development Goal
NGO	Non-governmental organization
NSE	Natural sciences and engineering
NSF	National Science Foundation
OAS	Organization of American States
OECD	Organization for Economic Co-operation and Development
R&D	Research and development
S&T	Science and technology
SET	Science, engineering and technology
SLE	School life expectancy
SMEs	Small and medium enterprises
SSE	School survival expectancy
SSH	Social sciences and humanities
SSI	Sex segregation index

STA	Science and technology activity (or activities)
STEM	Science, technology, engineering and mathematics
STET	Scientific and technical education and training
STP	Science and technology personnel
STS	Scientific and technological services
UIS	UNESCO Institute for Statistics
UNCSTD	UN Commission on Science and Technology for Development
WIR	Women in industrial research

Chapter 1

Overview: Gender indicators for science, engineering and technology

Introduction

During the past ten years, the global science community has increasingly recognized the importance of gender issues in SET. With the outputs of the UNCSTD's Gender Working Group (GWG) in 1995, the World Conference on Science in 1999, Beijing +5, the World Summit on the Information Society (WSIS), as well as initiatives by the European Union (EU) and the Organization of American States (OAS),[1] international science policy bodies are recognizing the importance of including women as equal participants, implementers and shapers of S&T, as well as recognizing their right to benefit equally from the application of S&T.

At the same time, there has been progress on other fronts. The rate of girls' and women's education and participation in S&T has improved over the last decade. However, evidence of the last ten to fifteen years indicates that the increased numbers of girls and women at lower levels of the system do not necessarily translate into increased numbers in higher levels of research and employment in the public and private sectors. Those women who do enter the science professions experience two kinds of segregation: horizontal and vertical. *Horizontal segregation* refers to segregation by discipline or sector. For example, while female enrolment in biological sciences is at or over 50 per cent in many countries, their participation in 'harder' sciences, such as engineering and physics, is less than one-third in most countries. We also see segregation in the sense that in many countries women are shifted to 'less desirable', low-expenditure science disciplines and systems (Women in Science, 1998). *Vertical segregation* relates to issues of employment and retention, that is, women do not turn their scientific credentials into employment in the science sector at the same rate as men, and when they do, they are not present in higher-level research, management and decision-making to the same extent as men (Glover, 2001; Rathgeber, 2002).

The purpose of this toolkit on gender indicators in SET is to promote the collection of sex-disaggregated data in science and technology activities (STA) for national and international policy, so that decision-makers, research institutions and development agencies (i) can better understand these issues, and (ii) formulate policy and programming based on this understanding. At the same time, it is intended to promote a common approach and coordinated methodology to ensure the systematic collection of sex-disaggregated data in S&T.

The toolkit begins by providing a survey of the different gender patterns of participation in S&T. It assesses information provided by sex-disaggregated quantitative data where available, and uses recent literature to discuss the reasons for differential rates of participation between women and men. Chapters 3 and 4 summarize international methods for measuring STA, personnel (STP) and qualifications, and occupations in terms of the kinds of information they provide and how they can be disaggregated by sex, age and other variables. Questions to be addressed include the definition of a range of activities in the economy – or sectors of employment – that can be considered to constitute or incorporate STA.

1. See Annex for a list of relevant initiatives and organizations.

With this information we attempt to provide an overall picture of the participation of women in S&T, both in industrialized and industrializing countries. It is hoped that a clearer understanding of the national and international patterns of women's participation in STA and the potential role they can play will convince policy-makers of the value of the contribution which women in SET can make to national development.

We shall highlight the different roles played by both women and men in S&T research, development and implementation at a national level. In considering these trends, we use the term 'gender' to refer to the varying roles and attributes of men and women in diverse social, cultural and political contexts. In order to 'engender' national and international data collection, it is necessary not only to understand and indicate statistically how women's roles and situations differ from those of men, but to understand how men also may be differentially represented in S&T and affected by its implementation. The goal is to understand statistical systems in terms of gender, rather than merely to insert female gender data into existing data collection systems. This toolkit is a first step in that direction, and it is hoped that it will cause more attention to be paid to the different roles of women and men in S&T for development, recognizing that the loss of investment and waste of resources (financial and human) which the attrition of women in science (the so-called 'leaky pipeline') represents is an unacceptable cost to any society.

The context for this toolkit is the recognition that 'the world is changing at a rapid pace, driven by science and technology' (InterAcademy Council, 2004, p. 1), and that despite the increasing rate of accumulation of scientific knowledge, lesser-developed countries are not seeing the same benefits from increased scientific knowledge as the richest countries. To redress this situation, according to the InterAcademy Council, attention must be paid to national capacity-building in science, technology and innovation. Unless developing countries create the indigenous scientific capacity to understand, engage in and contribute to international scientific research and innovation, they will not gain the capacity to apply and adapt S&T for national knowledge-based development. Nor can they expect to benefit from scientific innovation in other parts of the world, as past experience of technology transfer agreements and current intellectual property provisions demonstrate. S&T are increasingly important for economic growth, and there are concerns that the 'lagging' countries will continue to fall behind (InterAcademy Council, 2004).

An emphasis on national capacity-building leads to an emphasis on developing, attracting and retaining national S&T professionals, including those sectors of the potential S&T workforce that are not represented: women, minorities and the disabled. Promoting diversity in the workforce, that is, promoting a workforce that includes diversity of ethnicity, gender and culture, is seen as providing both the public and private sector with greater access to talent (by increasing the pool of qualified and skilled professionals), increasing innovation in research and output, providing a better match with clients and the market-place or the private sector, and encouraging a wider range of approaches, problem definitions and strategies – all of which can only increase the quality of outputs (EU, 2003; Emerson et al., 2001).

Increasing the participation of women in the S&T system is important and, as the InterAcademy Council argues, 'not only because it is the decent thing to do; in reality, societies simply cannot allow themselves to be deprived of the abilities and potentialities of women' (2003, p. 50). There is also the ongoing issue of gender equity to be taken into account and the question of the impact on research priorities and technology development if there were greater gender balance in science decision-making.

These issues are as relevant to developed as to developing countries. The EU initiated the programme 'Women in Science' to develop strategies to change the low representation of women in science in EU Member States, partially to ensure a base of skilled science professionals in an aging population and maintain economic growth. But the rationale for this initiative includes a critique of the European science system itself. It argues that the under-representation of women in science prevents the full realization of science in the region, in the first place because it is an 'unacceptable and unaffordable waste of human resources', but also because the under-representation of half of European society is seen to represent an imbalance, a distortion between science and society which decreases public trust and confidence in science. 'It is only by ensuring a greater gender equality in science, in its wide sense, that science will optimize the value that it brings to European society' (EC, 2001, p. 3).

An imbalance also exists in the way that S&T is applied for social development. Women engage with S&T in their daily lives in a way that, although experiential and non-formal, is nonetheless based on scientific and technological knowledge and practice. However, women's engagement with S&T for social development is a policy and research area that has been largely ignored. To the point that UNCSTD's Gender Working Group found in 1995 that after decades of S&T interventions in development, women's overall position actually declined relative to men's, and women have become disproportionately poor in comparision with the men in their communities (Gender Working Group, 1995).

For these reasons there is a great need for research, dissemination of data, and good cross-cultural statistics. The UN has called for sex-disaggregated data in all areas of development, including S&T, at the 1995 World Conference on Women and the 1999 UNESCO/ICSU[2] World Conference on Science. Other UN initiatives calling for sex-disaggregated statistics and gender indicators in S&T include UNCSTD's Gender Working Group, and the 2003 World Summit on the Information Society (WSIS).

Efforts to collect, analyse and disseminate sex-disaggregated data in S&T in a systematic manner are developing in various sectors: the principal international R&D/S&T data collecting agencies (OECD, UNESCO and Eurostat) have recently introduced gender variables in a systematic way in their survey questionnaires. In many cases this new data collection has been linked to analytical and policy developments. The OECD supports a Working Party on Gender Equity (under the Development Assistance Committee) and, under its Committee for Scientific and Technological Policy (CSTP), an ad hoc group on 'Steering and Funding Research Institutions' where issues of 'Women and Scientific Careers' are discussed.

In 1999 the EC proposed an action plan entitled *Women and Science – Mobilising Women to Enrich European Research*. Within the Fifth EC Framework Programme 1998–2002 (on research, technological development and demonstration activities), a work group (known as the 'Helsinki Group') was set up, one composed of civil servants and gender experts from the fifteen Member States and fifteen other associated countries. The task of the group is to discuss and exchange experience in gender policies, encourage the participation of women in S&T careers, and provide policy-relevant sex-disaggregated statistics and indicators. This active group, operating through the 'Women and Science' section of the Directorate-General responsible for research at the EC Headquarters, has produced many reports and recommendations on numerous 'positive action' measures. These include the establishment of national steering committees, the promotion of networks, the development of role models, monitoring schemes and gender mainstreaming tools (including legislative measures). Eurostat, the EC's statistical office, is closely involved in the group's work to improve the volume and the quality of relevant sex-disaggregated statistics and indicators.

Elsewhere, the Ibero American Network on Science and Technology Indicators (RICYT) in Argentina is collecting sex-disaggregated data on S&T in Latin America; the International Labour Organization (ILO) is increasing the quality of its data on women and men's participation in the formal and informal labour force; and Orbicom (UNESCO) is beginning to incorporate sex-disaggregated data where available (both qualitative and quantitative) into its Digital Divide Index.[3] In 1999, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) formulated regional indicators for the action areas emerging from the Beijing *Platform for Action* of the Fourth World Conference on Women, respecting the data constraints in the region. Indicators include: gender gap in ownership of agricultural land; division of labour by sex (ratio household to working time); gender inequality in earning; and gender-differentiation within the informal sector (ECLAC, 1999).

While promising, these initiatives just scratch the surface. The continuing dearth of reliable and systematic information on women's activities across all sectors leads to a lack of understanding of the 'different worlds' in which women and men live – in terms of access to education, work and resources, levels of health and nutrition, personal security and leisure time. More and better quantitative and qualitative information is needed to shed light on the gendered implications of S&T policy, and thus to serve as tools for policy-makers. The *Economic Advancement for Womem* resolution of the Beijing+10 Review calls

2. International Council for Science.

3. See Huyer et al., 2005.

BOX 1.1: EUROPEAN UNION HELSINKI GROUP

The Helsinki Group decided to approach the gendering of indicators on human resources from three angles: top down, bottom up, and gendering of the European national benchmarking exercise.

Top Down

- This approach involves the systematic introduction of sex/gender in regular statistical measurements of R&D and STA.

Bottom Up

A variety of approaches were devised:

- collecting existing relevant data about participation of women in science
- developing a global database with primary sex-disaggregated data
- collecting data in five groups: students, graduates, research staff in universities and research centres, research grants, boards of research institutions
- developing national profiles on presence of women in science in the Member States
- developing sets of gender(ed) indicators by commission to address:
  - how many?
  - vertical segregation (attrition)
  - horizontal segregation (discipline – occupational sector)
  - pay gap between men and women
  - fairness and success rates.

Since there is not enough data to 'fill' these indicators, the Commission will put forward suggestions to fill in the gaps.

The Benchmarking Exercise

The Research Council Resolution adopted on 15 June 2000, which build-on the Lisbon European Council Conclusions, calls on the Commission in collaboration with the Member States, to present a full set of indicators and a methodology for benchmarking the following four themes:

1. human resources in research and technology development (RTD), including attractiveness of S&T professions
2. public and private investment in RTD
3. scientific and technological productivity
4. impact of RTD on economic competitiveness and employment.

Two feasibility studies are being conducted to address gender and S&T productivity, on 'Patent Indicators by Gender' and 'Bibliometric Indicators by Gender'.

Source: EC, 2001.

on national governments to 'improve, promote and build capacity for the collection, dissemination and analysis of gender-sensitive statistical indicators and reliable statistics that are disaggregated by sex and other relevant factors in order to facilitate better policy development, monitoring and evaluation of the economic and social advancement of women' (CSW, 2005).

Women's contributions to S&T for development

Why gender? Women's contributions to national development

Gender can be defined as 'the set attributes assigned to women and men by history, society, culture and politics, which vary across time and space' (Lewis et al., 1994). Gender differences differ from sex or biological differences in that they are socially determined and may vary, according to local circumstances, within a region as well as between regions. Nevertheless, in all cultures of the world, women have clearly defined roles and responsibilities according to a socially defined gender division of labour (GDOL). Although in some cultures these roles are currently being questioned, in much of the world the GDOL continues to determine the differing roles and responsibilities – and therefore the differing needs and interests – of women and men.

Gender roles are not fixed, but change according to social, environmental, economic and technological trends. Social factors affecting these gender roles and gender-differentiated interests include:

- Institutional arrangements that create and reinforce gender-based constraints or, conversely, foster an environment in which gender disparities can be reduced.
- Socio-cultural attitudes and ethnic and class/caste-based obligations that determine men's and women's roles, responsibilities and decision-making functions.
- Religious beliefs and practices that limit women's mobility, social contact, access to resources and the types of activities they can pursue.
- The formal legal system that reinforces customs and practices giving women inferior legal status in many countries (Fong et al., 1996).

Women are central to development through their GDOL-defined roles, which include productive, reproductive and community management responsibilities:

Productive roles comprize work done by both women and men for payment (cash or in kind). It includes market production and subsistence/home production; for women this includes work as farmers, peasants' wives, wage workers, and small- and medium-scale entrepreneurs.

Reproductive roles pertain to childbearing and child-rearing responsibilities and domestic tasks undertaken to support the family. This includes care of husbands and children.

Women's **community management** role is defined as the allocation, provision and managing of items of collective consumption. It involves activities at the community level which are an extension of reproductive responsibilities, and which are undertaken in order to ensure the provision and maintenance of critical community resources, such as water, healthcare and education.

Although the GDOL varies across regions, there are several universal trends:

- Women continue to bear primary responsibility for childcare and housework, unpaid and uncounted work which remains economically invisible.
- Because women's community management role tends to be based on providing items of common consumption, for example clean water, and also tends to be informal and unpaid, it is not generally included in national systems of accounts.
- Men's community management role tends to be in a paid leadership capacity, set within the formal political framework of national politics. It has much more visibility at local and national policy levels.

Undervaluing women's work

As a result of their gender-defined roles, women make a major contribution to the production of food and the provision of energy, water, healthcare and family income in developing countries. Women's work is critical to the survival and security of poor households, and a starting point for poverty reduction. The importance of gathering sex-disaggregated data and developing gender indicators is illustrated by the underestimation of women's work in current approaches to labour force statistics and national

income accounts. Gender inequality structures relations of production and reproduction in different societies. While men play an important role in household livelihoods in much of the world, they generally do not engage in unpaid reproductive work, which takes up a great deal of women's time and effort. In addition, there is a marked inequity in the resources to which women and men have access in order to carry out their responsibilities, as well as in the value and recognition given to their contributions (ECOSOC, 2004; Kabeer, 2004).

The Beijing *Platform for Action* (DAW, 1995, Para. 68b) called for countries to 'Devise suitable statistical means to recognize and make visible the full extent of the work done by women and all their contributions to the national economy, including their contribution in the unremunerated and domestic sectors, and examine the relationship of women's unremunerated work to the incidence of and their vulnerability to poverty.' The data beginning to be gathered indicates that the informal sector provides the majority of employment in many developing countries, and has been growing rapidly over past two decades – in Latin America, seven out of ten new jobs are in the informal sector. In all regions of the developing world, informal employment outside of agriculture represents nearly half or more of total non-agricultural employment: 48 per cent in North Africa, 51 per cent in Latin America, 65 per cent in Asia and 72 per cent in sub-Saharan Africa. In developing countries, the proportion of women workers engaged in informal employment generally exceeds the proportion of male workers in informal employment: outside of North Africa, where 43 per cent of women workers are in informal employment, 60 per cent or more of women workers in the developing world are in informal employment (outside agriculture). This informal contribution makes up a substantial proportion of GDP. Women are also disproportionately engaged in non-standard forms of work, such as temporary and casual employment, part-time jobs, home-based work, self-employment and work in micro-enterprises (UNIFEM, 2000; Chen et al., 2005).

In some sub-Saharan Africa countries, the largest portion of the female non-agricultural labour force is in informal employment: 97 per cent in Benin, 95 per cent in Chad, 87 per cent in Guinea, 83 per cent in Kenya. Overall in sub-Saharan Africa, 84 per cent of women non-agricultural workers are informally employed, compared to 63 per cent of men; and in Latin America the figures are 58 per cent of women compared to 48 per cent of men. For Asia, both women and men are included in the informal sector at 65 per cent (Chen et al., 2005).

Women are entering the formal labour force in increasing numbers, although their percentage in the labour force compared to men remains low. The implications of globalization for women's work and incomes are mixed. It has benefited women in some regions more than others, according to country, industry or trade and employment status. It has provided new opportunities for some women, while others have lost jobs or markets. Other globalization-related effects may have caused a shift of work from the paid to the unpaid economy (and from men to women). Globalization and trade liberalization can nevertheless open up new economic opportunities for low-income women, if they are enabled to do so through supporting national policy, access to regional and national markets, and resource and input support (Carr, 2004).

In view of these data, we can see that a better statistical understanding of women's economic contributions will improve policy-making at the national, regional and international levels, and make significant progress towards reducing poverty. It has been pointed out, for example, that knowledge of women's economic contributions can be useful for human-resources planning, agricultural policies, policy on the informal sector, and adjustment and stabilization policies in time of economic crisis. More generally, better sex-disaggregated economic data will improve policy on employment, income distribution, social security, access to credit and training, and other related areas.

1997 Conference on women entrepreneurs in small and medium enterprises

In 1997 the OECD hosted a conference in partnership with IBM on the theme 'Women entrepreneurs in small and medium enterprises – A major force in innovation and job creation'. The conference brought together members of government, senior policy-makers, small business entrepreneurs, academics and other experts. The objective was to increase the understanding of the economic and social contributions of women entrepreneurs in OECD developing and transition economies (former Soviet-dominated countries in Eastern Europe), addressing the role of women in the business environment, in technology and innovation, globalization, international trade, man-

agement, finance and marketing. Once again, the need for more comprehensive quantitative and qualitative data on gendered trends was highlighted.

Conclusions of the conference include the following:

- Women-owned small and medium enterprises (SMEs) are reported to be growing at a faster rate than the economy as a whole in several OECD countries; however, the removal of a number of obstacles would allow their potential to be fully tapped.
- Collecting information and statistics on women business owners should be an integral part of the ongoing data collection on SMEs.
- Data are often incomplete, partly because of historical factors or national privacy laws, thus it is difficult to obtain national statistics on income and wealth by sex.
- Raising the visibility of and awareness about the economic and social role of women entrepreneurs and their businesses requires data and statistics.
- In the United States in the last few years the number of firms created and managed by women has grown twice as fast as those set up and managed by men.
- There are many indications of the growing importance of women-owned SMEs in OECD and non-OECD countries.
- Women in the transition economies are increasingly turning to entrepreneurship.
- The great majority of businesses run by women are in the service sector.

The report *Women Entrepreneurs in SMEs in the Asia Pacific Economic Cooperation (APEC) Region* (Chun, 1999) documents the state of women's entrepreneurship and discusses policy to foster women's entrepreneurship throughout the APEC region. It was noted that, despite the increasing economic and social significance of women's business ownership and management in the region, information on women's entrepreneurship has been seriously limited due to the lack of data and research.

Policy recommendations made in the report include the following:

- The amount of solid research information about women's entrepreneurship does not yet match the level of interest and need. Therefore, more information is needed about women business owners and their enterprises: their number and level of economic contributions, growth trends, the issues and challenges they are facing, and their goals and accomplishments. Such data should come both from official government censuses and surveys, and from non-governmental organizations, such associations, universities and institutes.
- The most successful programmes and initiatives thrive when there is oversight and organization. Therefore, it is recommended that governments create or designate an office or agency with oversight responsibility for programmes and initiatives to foster women's business development.
- The organization of education and training for new and growing women-owned businesses should be a key emphasis for such an office. Training in the areas of marketing, finance and technology are especially important.
- Financing is also the lifeblood of business development. Micro-credit programmes targeted especially toward women business owners have proven very successful, and should be encouraged.
- Frequently, training and technical assistance and micro-credit programmes can lead to the formation of women's associations. These associations play a vital role in providing a longer-term support network that discrete programmes cannot or should not provide. Encouraging the development of women's business associations is another key element of a coordinated approach to sustaining economic development for women entrepreneurs.

Women's contributions in other sectors

The importance of collecting sex-disaggregated data in other areas is similarly important for evaluating the contributions and situation of women, and consequently for devising appropriate national development policies. Differences in gender roles, customs and responsibilities mean that, in general, women experience less access to education and training, information, labour and other resources (Kabeer, 2003; Blackden and Banu, 1999). For example, while the gap between women's and men's access to literacy and education has narrowed, women continue to make up two-thirds of the 771 million illiterate people in the developing world, and girls make up the majority of the 115 million children without access to primary

school (UNESCO Institute for Statistics, 2005). Further, gender-based asset inequalities are a constraint to growth and poverty reduction overall, in view of women's role in food production, income generation and health at the local level.

Why gender, science and development?

The twentieth and twenty-first centuries have seen an unprecedented rate of development of scientific knowledge and technical applications. The pace of technological advance continues to accelerate, with great potential to improve the lives and livelihoods of the global community and profound implications for the global economy. In view of these trends, the role of S&T in promoting long-term economic growth, providing an enabling environment for innovation and research, and in building the citizen base for the science-based knowledge society is central to national development. Maintenance of an indigenous S&T workforce allows countries to be more than consumers of technological exports of other nations, and allows citizens to actively improve their own situations and economic well-being. A country that does not recognize this and consequently does not invest in national S&T capacity, will find itself falling further and further behind (InterAcademy Council, 2004; OAS, 2004).

S&T are 'basic components of human activity' (Papon and Barre, 1996) and as such provide the means for states to meet their economic, cultural and social needs. However, lack of resources and political commitment mean that many countries do not possess adequate scientific resources or infrastructure. Despite the recognition that 'access to scientific and technological knowledge and the ability to exploit it are becoming increasingly strategic and decisive for the economic performance of countries and regions in the competitive globalized economy' (EC, 1997), a comparison of ratios of gross domestic expenditure on R&D to GDP shows that the highest proportions of GDP are spent on national R&D in the industrialized countries.

At the end of the twentieth century, the OECD countries, with some 21 per cent of the world population, accounted for 58 per cent of the world GDP, around 80 per cent of the world gross domestic expenditures on research and development (GERD), and 72 per cent of its researchers. The world GERD/GDP ratio was at about 1.7 per cent, but this figure was heavily influenced by the developed countries (2.3 per cent), whereas the developing world accounted for just around 0.8 per cent. The latter ratio is, in itself, also strongly influenced by the weights of the People's Republic of China (1.0 per cent in 2000, 1.2 per cent in 2002, and 1.3 per cent in 2003) and India (0.8 per cent in 2000), whereas the vast majority of the remaining developing countries were, at best, still situated around the 0.2–0.3 per cent mark (UNESCO, 2004).

BOX 1.2: THE HOUSEHOLD

The household is a sensitive point of intervention for the implementation of positive change. As the micro-unit of reproduction, production, consumption and socialization, it is not only where the real effect of macro-level policies can be best assessed, but may hold a key to their success. This is where (1) the gender relations and social stereotypes that influence macro-level events are worked out in practical terms; (2) the flow and allocation of resources can determine levels of consumption, savings and investment, and labour-force participation, all of which are crucial to economic growth; and (3) the extent of household dependence on the scarce state resources will be based on its capacity to meet its members' needs.

It is well known that the most commonly used indicators of development are based on productivity. The output of domestic units, like a farm or a shop, and of those household members who work in the formal economy, is included in this. The labour input, remunerated or unremunerated, involved in this production is also counted. However, other aspects of the household economy – unpaid domestic work and services, for example – are not included; nor are activities in the informal sector. While the household is sometimes used as a unit for measuring consumption and distribution, estimates of average household income are made by mathematical computation (dividing total national income by the number of households), which hides the variations between and within households and does nothing to challenge the assumption that economic changes and policies are gender-neutral.

Source: DAW, 1991.

The facilitation of 'scientific literacy', an everyday working knowledge of science, will enable citizens to respond in an informed way to the technical issues of personal and national life. This kind of literacy promotes the development of a capable workforce, economic and physical well-being, and the exercise of participatory democracy. Scientific literacy is obviously necessary for the workforce required by modern industries, but it is also necessary for informed public involvement in determining public policy; for example, on public sources of energy, preservation and use of natural resources, where and how public roads should be built, what form of healthcare system will best serve the needs of a particular locality (Ayala, 1996). On the other hand, scientific literacy will also help communities and families to make appropriate decisions concerning resource allocation, diet, sanitation and community development, and to meet daily challenges in innovative ways.

One of the primary requirements for active participation in the global knowledge-based society is the development of national human resources for the maintenance of a country's science, technology and innovation capacity – both to engage in R&D and to develop a cadre of well-trained teachers of science at all levels. But perhaps the most convincing reason is articulated by the InterAcademy Council: 'surely the 80 per cent of humanity living in those countries should have a greater input into the creation of new knowledge, not only for the right to shape their own destinies, but for the insight and talent that they can bring to the rest of the world' (InterAcademy Council, 2004, p. 24).

Cultivating indigenous S&T capacity will be more effective if the abilities and potential contributions from sectors of the population that have been poorly represented to date are taken into account. Women and girls often face socio-cultural, economic and religious barriers to full participation in S&T. This failure to translate investment in women's education into investment in a stronger S&T workforce occurs for a variety of reasons, including lack of recognition of the biological and social roles of women; unequal distribution of responsibility for household work and child rearing; work cultures that fail to make room for women's varied responsibilities; less access to job training, retraining or advanced level courses; perceptions of what are 'suitable' occupations for women, physically and intellectually; and not actively seeking women candidates for positions and advanced training opportunities. Many ethnic, religious and other minorities also face discrimination in national S&T systems (InterAcademy Council, 2004; Huyer, 2004).

BOX 1.3: INDIAN WOMEN SCIENTISTS' ASSOCIATION PROGRAMMES FOR CREATING SCIENTIFIC LITERACY

The Indian Women Scientists' Association (IWSA) project on integrated approach to tribal empowerment conducted a survey assessing general health and nutritional status in western India. The surveys found that about 90 per cent of the population did not receive 50 per cent of the calories needed for adequate nutrition, and the infant mortality rate was very high (20–25 per cent). As a result, a training programme was set up which focused on:

1) the scientific process and value of immunization
2) nutrition
3) boiling and filtration of drinking water to avoid infection
4) use of smokeless stoves to avoid the health hazards associated with indoor smoke (conjunctivitis and blindness)
5) acceptance of latrines
6) home remedies
7) kitchen gardens.

Source: Gupte, 1996.

Why is the toolkit needed?

As we have seen, the way in which data in S&T are predominantly collected renders women and their concerns, issues and responsibilities relatively invisible. From existing data, we see that there are specific gender imbalances in a range of S&T sectors. To ensure women's equal access to economic resources, including land, credit, S&T, vocational training, information, and communication and markets, governments will need to develop tools that provide a clearer understanding of the contributions women make to national S&T systems.

The *Framework for Action* of the World Conference on Science (1999) states that all countries should contribute to the collection of reliable data, in an internationally standardized manner, for the generation of sex-disaggregated

statistics on S&T. An important step would be to follow up on the commitment made at the 1992 UNCED to:

> review policies and establish plans to increase the proportion of women involved as decision makers, planners, managers, scientists and technical advisers in the design, development and implementation of policies and programmes for sustainable development (UN, 1992, 24.3).

In its report to UNCSTD, the Gender Working Group noted that there is little sex-disaggregated data on S&T participation at national and international levels, no systematic approach or coordinated method for gathering this data, and, 'of equal importance for policy-makers', little data on the different effects of technology on women and men.

The importance of generating such disaggregated data is illustrated by the conclusions drawn from existing disaggregated data in education. According to the UNESCO manual *Gender-sensitive Education Statistics and Indicators: A Practical Guide*:

- Total fertility rates are highly correlated with female illiteracy and education.
- The correlation of GNP with GER (gross enrolment rate) is more marked for females than for males and for secondary than for primary education.
- There is a negative correlation between the percentage of female teachers and the female illiteracy rate; for example, countries with high female illiteracy are likely also to have a low percentage of female teachers.
- High correlation is found between the percentage of female teachers and the GPI for GER in primary and secondary education.
- There is high negative correlation between illiteracy rates and the GPI, particularly for primary education.

But perhaps the 'leaky pipeline' is the most convincing reason of all for the collection of sex-disaggregated data to inform national policy. The leaky pipeline is a concept that has been used to refer to the steady attrition of girls and women throughout the formal S&T system, from primary education to S&T decision-making. The loss of investment and waste of resources (financial and human), which the leaky pipeline represents, is an unacceptable cost to any society. The leaky pipeline will be discussed in more detail in Chapter 2.

Gendering statistics and indicators in SET

S&T statistics

S&T statistics (and indicators) are only one of many branches of institutionalized data collection. 'Statistics' can be defined as facts obtained from analysing information expressed in numbers, such as information about the frequency with which something happens. Statistics can also be considered a branch of mathematics that studies information expressed in numbers.

Raw statistical data may be interesting in their own right but can be even more useful if turned into indicators. An indicator can be defined as 'a set of statistics arranged to answer a specific question', to 'ring a bell' or 'give an early warning'. A statement such as '80 female students graduated in physics in 2003 in country X' provides some absolute information. However, putting this initial absolute figure in perspective with one or several other variables or dimensions – including time – will add value to the original information. 'Although this number of new female graduates has more than doubled in absolute terms since 1995, women still represent only 20 per cent of all students graduating in physics.'

One single indicator (or set of statistics) seldom is enough to serve as a basis for serious decision-making. Decisions must be based on a full set of combined quantitative and qualitative information. These indicators, however, do not indicate whether the situation is satisfactory or not; they only provide policy-makers with elements (tools) on which policy decisions may be based. If there is convergence between several sets of data and indicators, then some Realiztic conclusions may be drawn.

S&T statistics have much in common with other kinds of statistics, but possess their own derivations. One of the characteristics of S&T expenditure and personnel indicators is that they are often derived from other statistical series (such as demography, education and/or employment statistics). Such data were initially collected for other purposes than S&T, but they may, as an additional objective, be of interest to S&T policy.

The collection of sex-disaggregated S&T data has primarily focused on the formal S&T sector, for which much more statistical evidence is available – in the form of

education data on students and faculty staff, for instance – than for other fields of occupation.

It would be useful to collect statistics and indicators pertaining not only to the role of women in S&T, but also to their role in the global economy. As mentioned above, it is widely recognized that available statistics – such as the series of national accounts – do not reflect the informal work of women in the economy as a whole in undertaking subsistence, reproductive and productive activities (in agriculture and micro-level trade, for example).

For the most part, this toolkit will address the use of statistics gathered on 'formal' areas of STA, such as education, recognized S&T occupations, and R&D. In these areas, data are already collected and frameworks for collecting data are established. In addition, Chapter 5 will present some suggestions for the collection of data in areas where women's STA have not yet been formally recognized or incorporated into data-gathering guidelines or frameworks, such as the informal and subsistence sectors.

Sources of data on women's participation in S&T

Most countries undertake some kind of general data collection, usually through national bureaus of statistics. Population, employment, economics, industry, agriculture and foreign trade have now become well-established areas of statistics, while S&T and R&D statistics in general (including data for 'new' S&T areas, such as information technologies, environment, bio-sciences and nanotechnologies) are still relatively young branches and not yet considered high-priority areas everywhere. However, many non-S&T series may also serve the purposes of gender analysis.

The principal S&T data series currently available for international comparisons of STP are those related to education and R&D. Only the former series have always been systematically broken down by sex. It is worth mentioning, however, that, since the late 1990s, the gender variable has received very high-policy interest also in the R&D series and is now systematically included in the questionnaires of the leading international agencies.

With few exceptions, all statistics issued by international agencies (notably UNESCO and OECD) are based on official data supplied by their member countries (usually via a national bureau of statistics). Such information may first have been collected at home according to local practice and then rearranged to fit the conditions of international comparability. These international series are, as a rule, less detailed than many of the national series on which they are based, and sometimes represent the lowest common denominator of available data. For instance, where R&D personnel statistics are concerned, until quite recently countries were requested only to report full-time equivalence (FTE) data to the OECD and UNESCO. Even if they were available at the national level, neither Head Count (HC) data nor breakdowns by sex were requested. In other words, the collection of sex-disaggregated statistics has, until quite recently, not been a priority.

For many years the richest sources of information pertaining to gender policy for worldwide comparisons were undoubtedly the UNESCO education statistics, published annually in the *Statistical Yearbook* (since 1963), with their underlying databases. Since the late 1990s these databases have been handled by the independent UIS in Montreal, Canada. Important gender-related statistical and analytical work is also undertaken by Eurostat in Luxembourg. The bulk of today's international education statistics are collected in a common OECD/UNESCO/Eurostat questionnaire (with some specific agency-specific items). Most of the UNESCO Member States and territories (currently around 200) are in the process of economic and industrial development, and many of their statistical institutions are not yet fully operational. The OECD and Eurostat Member Countries (representing only a very small share of all the world's nations but the bulk of its R&D and innovation efforts) are economically more homogeneous and have well-established statistical routines. An important part of today's UIS work is capacity-building in developing countries, with a view to initiating or improving, among other things, statistical capabilities.

Defining STA and STP for statistical purposes

To define STA and STP for statistical purposes, our first task is to present, in terms of range of activities in the economy or in sectors of employment, a few principal definitions and areas of S&T addressed by this toolkit. We shall then discuss the currently used definitions of STP for statistical purposes, and, finally, what we mean by

S&T statistics and indicators. We shall also discuss why we are particularly interested in the role of women in S&T, basing our discussion on the latest available research and data. Here we shall be drawing on existing internationally adopted definitions and classifications, notably those of UNESCO, but also including data sets and definitions from the OECD and Eurostat.

The UNESCO definition of STA

The 1978 UNESCO *Recommendation Concerning the International Standardization of Statistics on Science and Technology* defines 'science and technology activities' (STA) as: 'systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical education and training (STET), and the scientific and technological services (STS).'

All these groups of activities, as well as a number of other related concepts and classifications, will be presented and discussed in more detail in Chapter 3.

What do we understand by STP?

UNESCO defines, in very general terms, STP as 'people participating *directly* in S&T … and, as a rule, paid for their services. This group should include scientists and engineers, and technicians... and auxiliary personnel.' This is not a clear-cut definition, given that it addresses the matter in terms of both educational and occupational criteria, which are sometimes hard to distinguish between. For example, the term 'engineer' may refer to someone who has received education in the engineering sciences, or to someone who is working as an engineer. The toolkit will therefore have to draw on both educational and occupational criteria to discuss matters of STP. In other words, to understand the breakdown by sex of participation in STA, it is important to examine both the education status (or level) of STP, and where and in what positions they are employed (occupation). These matters will be discussed in Chapter 4.

Conclusion

A great deal of qualitative research has been done on the STA in which women engage to fulfil their daily reproductive and productive responsibilities (see Appleton, 1995). It is clear that their everyday, experiential contributions to S&T are under-reported because they are neither part of the official (cash) economy nor fully covered in the censuses. Nor are their contributions in formal S&T sectors, activities and professions adequately documented or understood. More efforts are needed to shed further light on this essential issue of measurements.

In so doing, policy-makers will not only advance and empower the women and girls in their country, but improve national progress for sustainable development and human well-being. As UN Member States agreed in the *Beijing Declaration* (DAW, 1995, Para. 19):

> It is essential to design, implement and monitor, with the full participation of women, effective, efficient and mutually reinforcing gender-sensitive policies and programmes, including development policies and programmes, at all levels, that will foster the empowerment and advancement of women.

Chapter 2

The leaky pipeline: Gender issues in science, engineering and technology

A gender perspective[1]

There are many other reasons for encouraging women's participation in and contributions to SET. Gender-equity reasons alone constitute a strong argument. The right of women to equal access to advancement and empowerment has been a central theme in the UN and at UN conferences from the foundational 1945 UN *Charter of Rights* to the Vienna Conference on Human Rights, and more recently at the Beijing World Conference on Women (1995), the World Conference on Science, the World Summit on Sustainable Development (2002) and the World Summit on the Information Society (2003).

There has been progress in this area. The rate of girls' and women's education in S&T has been improving over the last decade. However, evidence of the last ten to fifteen years indicates that despite these improvements, the increased numbers of girls and women at lower levels of the system does not necessarily translate into increased numbers in higher levels of research and private-sector employment. Worldwide, it appears that women scientists do not transfer their scientific qualifications into scientific occupations to the same degree as men. Data and research in both the university setting and industry indicate that the representation of women consistently decreases as one moves up in the system. Women's rate of temporary and shorter-term work is greater than that of men's, and women are paid significantly less than men. As well, women tend to be concentrated in 'softer' or biological and life sciences and less prestigious fields of science (Glover and Fielding, 1999; EU, 2003; Glover, 2001).

The 'leaky pipeline' is a concept that has been used to refer to the steady attrition of girls and women throughout the formal S&T system, from primary education to S&T decision-making. And although some of the 'leaks' are currently being patched, we continue to see substantial loss at all points along the pipeline.

The leaky pipeline

There are four major points at which barriers to women and girls' participation in S&T, or leaks in the pipeline, can be identified:

- Access to education
- Female participation in science education
- The S&T workforce
- S&T for social development.

In addition there are issues related to sociocultural expectations and roles, institutional barriers and qualification barriers which cut across all points of attrition (Evans, 1995).

Gendered trends in access to education

Social preferences for male children are common in many cultures of the world. As a result, girls are disadvantaged before and at birth, during their childhood, and on into adulthood. In some countries in South and East Asia, for example, amniocentesis and abortion of

1. This chapter is based in large part on Huyer, 2004.

BOX 2.1: WOMEN, SCIENCE AND WORLDVIEW: THE GENDER EFFECT

In a psychology class some years ago, I learned about a group of people who were not fooled by an optical illusion, which fooled almost all the rest of us. When asked to judge two lines which were of identical length, but with arrows at the ends pointing in opposite directions, we characteristically 'see' line (b) to be longer than line (a), because of the pattern of which it is a part:

(a) 

(b) 

In a classic work by Segal, Campbell and Herskovits, *The Influence of Culture on Visual Perception* (1966), groups who lived with few lines were found to be less susceptible to the illusion. A part of their culture, the way they were raised, the world in which they lived, left them free of the perceptual bias that had caught me. I learned that in a rounded world, having homes without corners, using few straight lines, their perception of the line and pattern was different from mine.

So also, when little boys and girls are raised differently, as they are in the USA, they acquire different perspectives and perceptions. Sons and daughters continue to be raised differently. The biological differences between them are real, as are the interactions of biology and culture. For humans, culture overrides much of biology. I believe that while the gender effect does not relate to the ability to solve problems, it probably does affect the processes by which they are solved. Instead of seeing a 'deficit' model in this diversity, however, I view a 'difference' model and see strength in those differences.

Many of us work long and hard to get more women into science and engineering careers. There are a lot of reasons why we do this, reasons related to economics, equality of access, relative employment stability and utilization of talent, as well as personal satisfaction and intellectual challenge for the women involved. We also do this because S&T are not as good as they could be when 'other' perspectives are missing. If women and other groups and cultures are excluded, other viewpoints of the world are being lost.

Science itself uses the argument of diverse perspectives to support the idea of mixed age groupings on science faculties, international exchanges of scientists or multi-national research institutes. A study by Albert Teich [*Scientists and Public Affairs* (1974)] of European research laboratories such as CERN found that interaction among colleagues with different cultural histories and traditions affected the process of the research, although not necessarily the conclusions. These processes suggest new questions, new connections and new relationships, all matters of great importance to activities on the frontiers of knowledge.

Diversity among the doers of science may lead to awareness of alternatives: recognizing that a troop of baboons may be held together by male aggressive behaviour or by female friendships may lead to a truer assessment of the social organization. Diversity of perspectives may make the difference in designing a study of hypertension which involves only males or which includes females for comparison. It may only mean developing an algorithm through one thought process rather than another. But when there is a mass exclusion of a group of people – whether intentional or coincidental – with a different set of perspectives and worldviews, the profession is the poorer.

In view of the pivotal role of S&T in our lives, I believe we must be especially careful that these fields are not an exclusive club. All people must be prized for the different perspectives they can potentially bring to the scientific process. The talents of all interested and able people must be carefully nurtured, lest an indifferent or negative society turn them away because of their differences from the majority of the present participants. I'm glad I learned about the people who were not fooled by the optical illusion. Maybe a more heterogeneous worldview in science will keep us honest about a lot of other things as well.

Source: Malcolm, 1996.

female foetuses, female infanticide, and social customs of feeding boys and men before girls and women are thought to account for the imbalance, in sex ratios in favour of males in those regions. Such practices also result in poorer health, so that women are less able to withstand the physical stresses of childbirth and child rearing (for instance, breastfeeding). In many regions of the world, girls and women often have lower rates of nutrition (UNIFEM, 2000).

Taken in total, global education rates for girls at the primary level and literacy levels for women remain lower than those for boys and men:

- Two out of three of the 115 million children in the world who do not attend school are girls – and there are 42 million fewer girls than boys in primary school.
- Girls who miss out on primary education grow up to become the women who make up two-thirds of the world's 771 million illiterate adults.

Factors affecting the lower enrolment of girls include:

- Choices to invest in boys' education at the expense of girls, who are kept at home to help with domestic chores.
- Preconceptions that girls do not 'need' education as much as boys, since they are often not expected to move into paid employment outside the home.
- Early marriage and motherhood: in Nepal, 40 per cent of girls are married before age 15.
- Armed conflict. Girls are more vulnerable to rape, sexual violence and exploitation than boys. It is estimated that approximately 100,000 girls directly participated in conflicts in at least thirty countries in the 1990s as fighters, cooks, porters, spies, servants or sex slaves (UNESCO, 2003).

Once girls do reach school-attending age, other factors mitigate against their access to education. Even if girls start school, they are far less likely to complete their education. A 6-year-old girl in South Asia is likely to spend six years in school, compared with nine years for a boy. Living in the countryside widens the gap: a girl living in a rural area is three times more likely to drop out of school than a boy in the city. Concerns about lack of acceptable or appropriate sanitation facilities at schools (latrines, etc.), and sexual harassment are also factors (UNESCO, 2003).

It should nevertheless be noted that gender trends in educational enrolment vary widely from region to region and even from country to country. The sustained efforts to promote girls' education in many countries in recent years, epitomized by the Education for All initiative and supported by agencies such as the World Bank, are producing results. According to UNESCO, girls' enrolments have increased faster than boys' in the period 1990–2000, as overall access to primary education also increased.[2] Sub-Saharan Africa showed the highest relative increase of girls' enrolment (38 per cent), while South and West Asia and the Arab States show lower rates of increase (19 per cent and 17 per cent). Latin America and the Caribbean have seen large increases, and are close to achieving universal primary education, with net enrolments of 97 per cent – in many countries in the Caribbean, female educational enrolment rates are higher than for males. Eastern Europe also has seen high rates of literacy and primary enrolment (UNESCO, 2003).

Education in S&T subjects

At school, girls are in many instances discouraged from learning S&T, either consciously or unconsciously as a result of parents' and teachers' biases.[3] S&T is often not considered an appropriate occupation for girls and women, for reasons ranging from lack of intellectual ability to expectations that women work in the home. A study in Mali found that almost one-third of households surveyed made different enrolment choices for girls and boys because boys were considered to be more intelligent (UNESCO, 2003).

Studies in both the North and the South show that teachers tend to answer boys more often than girls in math and science classes, and pay more attention to girls in non-science classes – practices that send clear messages about gender capacities.[4] Teaching materials, textbooks and lectures tend to depict S&T as a male do-

2. The exceptions are Chad, Benin, Burkina Faso, Guinea-Bissau, Mali, the Niger and Pakistan. Poverty is a major factor in those countries that have a high level of gender disparity in school enrolments.
3. Studies show that women scientists tend to have fathers or mothers who are scientists in greater proportion than their male colleagues. See Rathgeber, 2002; National Research Council, 2001.
4. See Margolis and Fisher, 2002.

main, depriving girls of role models. There is increasing evidence that girls benefit from S&T teaching curricula that emphasize hands-on activities and application to everyday life and the environment, reflecting women's important contributions to agroforestry, natural resource management and human health in much of the world. A narrow focus on the technology sector in the curriculum, while appealing to boys, can alienate girls, who are more interested in understanding how the technology fits into a larger social, environmental or work context. The preconception that scientists are objective and distanced observers of their world promotes a view of science that removes people and the social dimension from the inquiry, consequently alienating many girls and young women for whom their relationships with teachers and friends are important parts of their educational experience (AAUW, 2000; Bissell et al., 2003; Dundar and Hayworth, 1999).

At the tertiary level in general, levels of enrolment for women have increased to 46.8 per cent globally, with the greatest gains in absolute terms made in developing countries. However, there are wide regional variations in participation: in OECD countries and Central and Eastern Europe, gross enrolment rates (GER) at this level stand at 45 per cent, while in the great majority of developing countries, the percentage is under 30 per cent. Of those countries that gather sex-disaggregated data, women make up the majority of students at this level in most European countries, Latin America and the Caribbean, and North America, but are poorly represented in sub-Saharan Africa, with varying rates of enrolment in the Arab States (where two students out of ten are women in Mauritania). In several countries in Asia and the Pacific, female enrolment is less than two-thirds of male enrolment (UNESCO, 2003).

Tertiary level enrolments in SET subjects indicate further evidence of a gender gap. In many regions the participation of women in biological and life sciences has increased and continues to increase. Judith Glover (2001) refers to the 'feminization' of the biosciences in Europe, where women make up over 50 per cent, while in the US primatology is dominated by women, who receive over 80 per cent of the PhDs awarded in the discipline (Schiebinger, 1999). At the same time, women's level of representation in 'harder' sciences such as physics and engineering is persistently low around the world. In the US there is one woman for every five to six men who graduate from an engineering programme, and while the percentage of women in chemical and agricultural engineering is slightly higher, in electrical and mechanical engineering it is lower – less than 14 per cent (NSF, 2003). Similar to the situation in Europe, in the US women earn more than half of the baccalaureate degrees in the biosciences, but only 21 per cent in physics. The numbers for computer science are especially concerning: in the US and Canada, female participation in the technology sector is declining. In 1985, women received 37 per cent of all US computer science undergraduate degrees, and by 2000 that number had fallen to 28 per cent. At the top US schools, the number is now below 20 per cent (Salkever, 2004).

In Europe, male graduates tend to outnumber women graduates in science, mathematics and computing programmes (except in Belgium and Spain), and in engineering programmes. The average percentage of women graduates in science, mathematics and computing in the EU is 35.7 per cent, down from 41 per cent in 2000.[5] National percentages range from 25.5 per cent in the Netherlands to 49.8 per cent in Portugal. Women made up 20.6 per cent of engineering graduates, though in real terms there was a decrease in head count from 1,800 in 2000 to an estimated 1,200 women in 2001. Germany has the lowest proportion of women engineering graduates, with 11.8 per cent, and Italy the greatest proportion, with 34.4 per cent (EC, 2003).

These trends are seen elsewhere in the world. Table 2.1 lists data on women's participation in science and in engineering, manufacturing and construction in selected countries.

The S&T workplace

As we have seen, the rate of girls' education, as well as the education of girls and women in S&T, has been improving over the last ten years. This is a result of improved teaching methods and curricula and progress in many regions towards universal education at primary and secondary levels. In many countries, representation of women in tertiary science courses is at or close to 50 per cent. Given these positive

5. Health sciences are not included in this category, which may account for the lower number in comparison with other regions.

Table 2.1: Women's participation in science and in engineering, manufacturing and construction

Country	Science (% women)	Engineering, manufacturing and construction (% women)
Costa Rica	40	28
Mexico	46	24
Bangladesh	29	10
Brunei Darussalam	51	38
Cambodia	21	1
Georgia	67	27
Israel	45	24
Japan	25	13
Lebanon	47	21
Korea	45	28
Turkey	43	24
Eritrea	4	2
Ethiopia	23	5
Madagascar	37	20
Mauritius	54	19

Source: UIS, 2003.

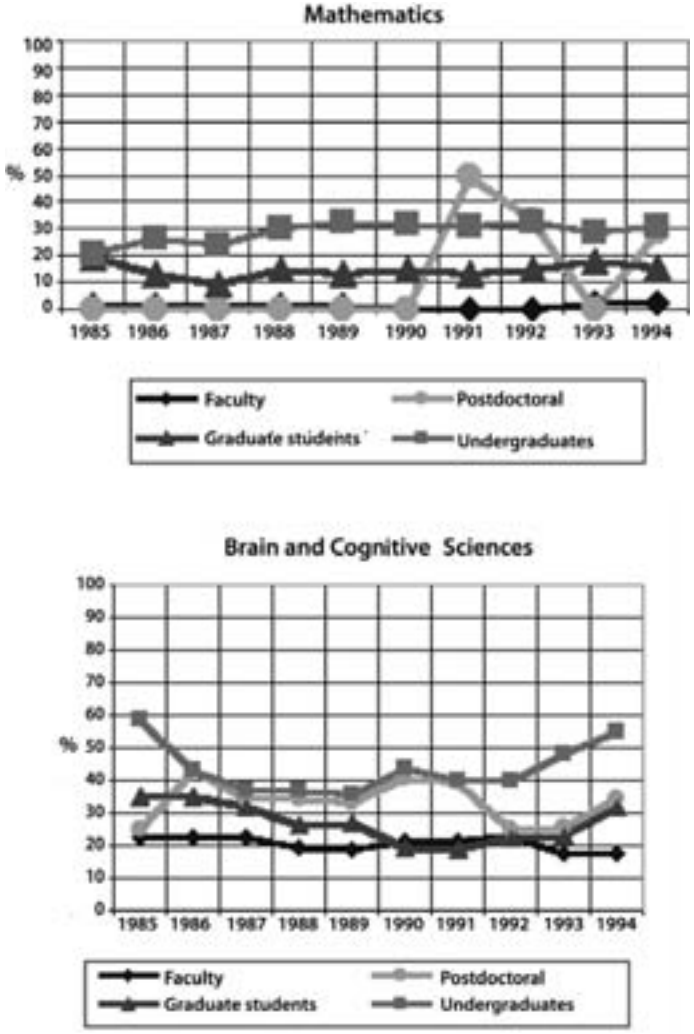
trends, it is easy to assume that achieving gender parity in science, technology, engineering and mathematics (STEM) will be an inevitable result of the increased numbers of girls and women coming up through the system.

Unfortunately, evidence of the last ten to fifteen years indicates that increased numbers of girls and women at the lower levels of the system has not translated into increased numbers at the upper end. This trend is illustrated by a 1994 study of women faculty in the School of Science at the Massachusetts Institute of Technology (MIT) (see Figure 2.1). It found that of the 209 tenured faculty members in the School, 15 (8 per cent) were women – compared to 194 men. It was also found that this figure of 8 per cent had not changed in the previous ten and possibly twenty years, despite major increases in enrolments of women in undergraduate science courses – an indication that attrition of women through the system was ongoing and unchanging (MIT, 1999).

Worldwide, the translation of 'scientific human capital' into professional scientific occupations is low for both men and women, and part of the global science capacity-building question. Nevertheless, the rate of translation is lower for women: women scientists do not translate their scientific qualifications into scientific occupations to the same degree as men.[6] The fact that many highly trained women are subsequently 'lost to science' (EC, 2000, p. viii) is a great loss in investment for countries, especially when added to the brain drain. In other words, recruitment of women into STEM professions is lower than it should and could be, considering the performance of girls and women in science education, and this represents a loss of investment and waste of resources.

6. For example, analyses of first destinations shows that there are over three times as many women as men science graduates in non-professional employment in science in Britain (Glover and Fielding, 1999).

Figure 2.1: Per cent of women at each stage of their career in Departments of Mathematics and Physics in MIT's School of Science, 1985–1994



Source: MIT, 1999.

Recruitment

When we look at recruitment issues, we see that for those women who do enter the science professions, two kinds of segregation exist: horizontal and vertical. Horizontal segregation constitutes segregation by discipline or sector. As we have seen, most women scientists work in the bio- and health sciences, with low representation in the 'hard' science disciplines (such as physics and engineering). The EU figures separate natural sciences, engineering and technologies, medical sciences, agricultural sciences, social sciences and humanities. The numbers for women in Sweden, for instance, are:

Natural sciences	30.5 %
Engineering and technologies	19.0 %
Medical sciences	51.2 %
Agricultural sciences	40.9 %
Social sciences	43.3 %
Humanities	43.7 %

Another kind of horizontal segregation was referred to at the European Regional Conference of the 1998 World Conference on Science (WCS), on 'Women in Science – Quality and Equality, Conditions for Sustainable Human Development' held in Bled, Slovenia. Participants at the meeting argued that women are often squeezed out of the competitive, high-expenditure, 'glamourous' R&D systems, and pushed into low-expenditure systems 'as a kind of "back-up" human resource' (*Women in Science*, 1998). In Central and Eastern Europe the presence of women in publicly-funded research institutions and universities can be seen as an opening up of spaces vacated by male scientists who shift to better-paying and more prestigious posts in the private sector or abroad. In Romania, shifts in women's participation in the labour force were initiated by economic restructuring in the early 1990s, such that women's rate of unemployment increased in relation to men's (UNDP, 1998). More data is needed on this trend of women entering scientific fields in greater numbers when men do not choose to enter these fields for reasons of prestige or remuneration. In this respect, the increasing feminization of science is a result of 'loss of resources, status and diminishing capacity to generate excellence in research' (*Women in Science*, 1998).

The NSF found that women and men take qualitatively different academic jobs. Women tend to work in jobs and institutions that stress teaching over research. One study found that women placed higher preference on student quality, teaching load, collegiality and interaction within departments, opportunities for joint work, and female representation on faculty, while men tended to consider salary and benefits as priorities for job acceptance (NSF, 2003). These preferences on the part of women for qualities and duties that are not well-rewarded in the academic performance review system have implications for vertical system segregation (see below).

BOX 2.2: EMPLOYMENT PATTERNS OF SET GRADUATES

A UK study on employment patterns of SET graduates was undertaken to examine how the country could maximize the return on the investment made in training such graduates and thereby address skills shortages.

The study found:

- A minority of SET graduates are employed in SET occupations, as defined in this study (40 per cent of men and 25 per cent of women). From 1992 to 2000 an increasing number of female SET graduates were employed within the key SET occupations, save for those generally regarded as the most 'junior', scientific technicians.
- Women with SET degrees are economically less active than their male counterparts or female non-SET graduates.
- About 24,000 women SET graduates returned to employment in the year 2000, of which about a third returned to SET occupations.
- There are significant issues for women seeking to return to work after extended breaks, and the barriers may be greater for those in SET.
- Employers are unlikely to make the investment needed to attract returners because the likelihood of finding and successfully recruiting women returners is very low for any individual company.

The study concluded by suggesting that there is a role for government programmes designed to help women to return to employment in SET.

Source: Office of Science and Technology, DTI, 2002.

Retention

Vertical segregation relates to the issues of retention and advancement. Data in the UK (supported by data in the US) show that women with high-level scientific qualifications tend to leave the labour market in their late 20s and early 30s, during their prime child-bearing years. Studies also show that 44 per cent of men are employed for at least ten years at a stretch, while only 13 per cent of women are employed for the same period, and that three-quarters of male employment periods last at least five years compared to one-third of female employment periods. As a result, women's scientific careers tend to be less stable and are characterized by shorter-term and temporary work rather than continuously-held positions (Glover, 2001). A US study found that women's rate of exit from science is higher than in other professions and twice that of men. In many OECD countries, women scientists and engineers working in the industrial sector are under-represented and more likely to leave technical occupations – and the labour force in general – than women working in other sectors (Preston, 1994; EU, 2003). While there is not as much data in developing countries in this respect, Rathgeber (2002) found in her study of gender patterns of science careers at CGIAR centres[7] that women are much more likely than men to be represented in the shorter-term and temporary contract science positions.

Returning to the workforce after leaving for child-rearing poses another set of difficulties. Many women attempting to return to the private sector find that their skills need updating, especially if they have been away for more than one to two years. Additionally, if unemployment rates are high, candidates with no break in employment experience are generally considered more desirable than those who have been out of the workforce (Salkever, 2004).

Finally, those women who do stay in the profession are more likely to defer childbearing or to remain childless. In the UK, studies indicate that women scientists and technologists are more likely than women in the health and teaching professions to defer childbearing or put it off entirely. In the US, women scientists marry less and have fewer children than their male colleagues. In the US, 94 per cent of male scientists are married, compared to 70 per cent of female scientists. In certain

7. The Consultative Group on International Agricultural Research (CGIAR) supports a system of sixteen international agricultural research centres in twelve developing and three developed countries.

disciplines, the number of unmarried women is higher: 38 per cent in chemistry (compared to 18 per cent unmarried men) and approximately 35 per cent in physics. Interestingly, a large percentage of women physicists tend to be married to other scientists, which affects job prospects (see below). In the US, 37 per cent of women scientists over the age of 50 are childless, compared with 9 per cent of men. Studies in developing countries have provided similar numbers. In their study of scientists in Ghana, Kenya and Kerala in agriculture, environment and natural resource management, Campion and Shrum found that 95 per cent of male scientists were married, compared to three-quarters of women scientists, that women were more likely to postpone a family, and 16 per cent did not have children at all. In Rathgeber's study, over 25 per cent of women were single compared with less than 10 per cent of men; and 51 per cent had children, compared with 80 per cent of men (Bagenal, 2004; Campion and Shrum, 2004; Rathgeber, 2002; Schiebinger, 1999).

The implications for women's family life will, of course, also affect potential for advancement in their profession.

Advancement

In the UK the main activity for men with scientific qualifications is management, for women it is teaching and non-professional activities not requiring a university degree.[8] These findings are supported by studies in other countries – for example, in the CGIAR centres, men are over-represented in the higher, more senior research and management positions (Rathgeber, 2002).

These findings were corroborated at the WCS Slovenia women's forum in 1998, where concern was expressed about the implications for decisions made on S&T research and orientation:

> The absence of women scientists in top managerial positions in educational and research institutions and also at ministerial level, excludes female voices in an equal partnership in decisive decisions on the current and future orientation of S&T (*Women in Science*, 1998).

In its survey on research on gender differences in science careers, the NSF found that,

> Taken as a whole, the body of literature we reviewed provides evidence that women in academic careers are disadvantaged compared with men in similar careers. Faculty women earn less, are promoted less frequently to senior academic ranks, and publish less frequently than their male counterparts (NSF, 2003, p. 1).

The lower number of women in senior positions can be attributed to a limited extent to the generally younger age of women in science, but a wider range of factors combine to produce a 'glass ceiling', such as work–life balance, gendered patterns and approaches to productivity, and performance measurement and promotion criteria.

In the 1995 MIT study, faculty women were interviewed about their experience in the School of Science. The more junior faculty women did not feel that they had been discriminated against, but felt that family–work conflicts may have been more of a factor in their careers than those of their male colleagues (MIT, 1999). In addition to the professional price paid for taking time off to have and care for children, married professional women spend more time overall in domestic chores and childcare duties than their husbands. In the US, professional women work roughly 15 hours per week more at home than their husbands and sleep 20 minutes less per night. Those with children sleep 40 minutes less per night than their husbands (Schiebinger, 1999). In those countries where domestic help is more common, this situation may vary. However, women scientists in the CGIAR centres appeared to experience the same difficulty in reconciling work and home life, although men to a lesser extent also complained about not being able to spend enough quality time with their families. Nevertheless, men were more likely to spend extra time on the job and to work on weekends than women (Rathgeber, 2002). Campion and Shrum (2004) found that the women scientists in their study were perceived as the primary caregivers at home, and that such perceptions affected their career prospects. Opportunities for fieldwork and travel were limited for the women in their survey, who experienced restrictions related to the assumption that traditional familial roles of wife and mother take priority, in contrast to men who are seen to be required to travel in their role as family providers.

For the women in the latter study, restrictions on travel were seen to be major inhibitors of their professional opportunities, both now and in the future. The survey

8. That is, as technicians.

found that women's professional networks and contacts tended to be local and national. Women scientists did not have the same opportunity to travel abroad for advanced education or training, and were less able to participate in international conferences.[9] As a result, the women in the survey were less aware of the professional and funding resources available to them; they published less often in foreign journals; and they tended to have a more regionalist understanding or perspective on environmental issues in comparison to their male colleagues, whose views tended to be more influenced by first-world perspectives and analysis. The repercussions of this situation have not been studied, although the effect on promotion rates for women with fewer publications in international journals is probably evident. Additionally, the authors argue that as scientific networks become more global, differences in networks and opportunities may restrict the scientific careers of women, even if their numbers are increasing (Campion and Shrum, 2004). While Rathgeber does not address this topic directly, it is notable that women scientists in the CGIAR system tend to be nationally recruited while men are more likely to be internationally recruited. She also found that the women in her survey spent more time on scientific research per se than men, who spent more time fundraising, proposal writing, promoting partnerships and networking, on official travel, and attending conferences.

In both developed and developing countries, professional women tend to marry professional men and scientists of an equal or higher position (Rathgeber, 2002; Schiebinger, 1999; Campion and Shrum, 2004; Bagenal, 2004). This has several layers of implication for women. Since they often marry a man senior to them, they are expected to follow their husband when he relocates for professional advancement. For women who marry fellow scientists, this problem is exacerbated by the fact that other than in high-intensity academic areas, such as the San Francisco Bay Area and Boston, it can be difficult for both scientists to find full-time work in their discipline. Women often end up taking on part-time lectureships, moving into the private sector, switching professions, or dropping out of the workforce. While professional couples more frequently are living in separate cities or even separate countries or continents, this is still rare and very difficult to manage with children at home.

Performance and productivity measurement

The NSF review of gendered career patterns (2003) found that faculty women earn less than their male colleagues, are promoted less frequently and publish less frequently. These results emerged even when studies were controlled for factors such as age/experience, academic rank and family characteristics. As a result, most studies show that women earn less than their male counterparts, and participate less in senior societies, committees and prestigious activities.

In academic positions, level of scholarly productivity is one of the major factors in explaining women's lower position in the system. Based on a framework established in a time when professors and researchers were primarily men supported by wives at home, scholarly review processes rarely take into account gendered patterns of productivity and career trajectories, such as domestic and child bearing responsibilities, approach to publishing, and focus on teaching rather than research.

For example, concerns are expressed that not only do count-based and publication-focused measurements of employment experience and publication record penalizing women, they do not properly reflect the quality of contributions made by both men and women. Many studies show that women prefer to focus on teaching and interaction with students (NSF, 2003). Feminist scholars have pointed out that years of employment are not a good indicator of experience, and that the concept of 'academic age' is a more accurate measurement (Glover, 2001).

Studies on rates and patterns of citation have revealed interesting (and often gender-biased) trends. While straight index counts will often indicate lower production of scholarly publications by women, use of a quality-weighted index that takes into account the number of times an article is cited will increase the rating for women. A famous study by Sonnert and Holton (1995) of 699 scientists in the US found that women tended to value work that was more comprehensive and synthetic, so that while they had fewer numbers of publications, these publications tended to be more widely cited. In biochemistry, J. Scott Long found that the average paper by a woman was cited 1.5 times more often than that of a man (1992). It has been

9. The reasons for lack of travel were not made clear, although the authors conjectured that reasons of family and security could also be related to decisions on investment in female education.

found elsewhere that women tend to be more cautious, thorough and attentive to detail in preparing work for publication. This is partly due to a sense of insecurity about the quality of their work, as well as a sense (often based in reality) that their work is not rated as highly as that of their male colleagues. Studies show that males have more confidence about their abilities than females, regardless of whether this confidence is merited. The result is that women's work often has to be seamless to be valued at its worth (Schiebinger, 1995; Rathgeber, 2002; Margolis and Fisher, 2002).

As discussed earlier, Campion and Shrum (2004) also found that although women published at roughly equal rates with men, they tended to publish in national journals. Men were more likely to publish in international journals, possibly due to their larger international networks and advanced training abroad.

Private-sector industry

Women scientists have found that structural and systemic barriers and disadvantages also apply in the industrial workplace. A study of women in the oil and gas sector in Canada in 2002 found that women made up 24.2 per cent of employees in the sector, with 60 per cent of those in clerical, sales and services positions.[10] For example, women engineers in Canada are more likely to work in industry sectors such as utilities (19 per cent), consulting (20 per cent), education (21 per cent) and government (25 per cent) than in manufacturing (16 per cent) and construction (10 per cent). In Europe, women make up 15 per cent of industrial researchers, compared to 31 per cent of government researchers and 31 per cent of researchers in higher education (Emerson et al., 2002; EU, 2003).

Many aspects of employment requirements, expectations and culture in the industrial sector (including oil and gas) pose difficulties for women interested in working and advancing in the industry. As a 'highly competitive, profit-driven and fast changing' sector (Emerson et al., 2001, p. 6), perceptions of what is required from employees for competitiveness in the industry have been weighted heavily against the realities of women's lives. Employees are encouraged to change positions every three to five years in order to gain the broad experience necessary to be considered management potential. Changes in position are often associated with fieldwork for varying lengths of time, as well as changes of location, something which is often more difficult for women than for men. Other factors mitigating against women's participation and advancement in the sector include: a corporate culture in which men feel more at home and valued, and where in some cases it is acceptable to intimidate and discriminate against female colleagues; sexual harassment, isolation and exclusion from informal networks; and problems linked to the different modes of communication between men and women. Women may also prefer a more balanced life with time to pursue other interests, a perspective that can be considered to indicate a lack of commitment to the company. And finally, women can also be overlooked or ignored, and their opinions and achievements discounted. With fewer women in senior positions, there are fewer mentors and role models for junior women, and a male-dominated culture is allowed to predominate (Emerson et al., 2001; EC, 2003; Hurley and Fagenson-Eland, 1996; Ragis and Cotton, 1996).

Persisting gendered perceptions of women's ability

In addition to these systemic and situational barriers in both research and industry, there remains an element of what can only be termed sexism, despite admitted gains made by women in the workforce over the past twenty years. A study by Chicago Women in Trades – which supports women in plumbing, electricity, construction and other areas – found that more than a third of the women who left their industries heard remarks on the job accusing them of being lesbian, whether or not they actually were; almost half heard remarks about their race or ethnicity (Teichgraeber, 2004).

In academia, when Fay Ajzenberg-Selove applied for a position in physics at a university in the US, she was not hired because (i) she was 'too old' (46) and (ii) 'insufficiently active in physics'. The first reason given is illegal in the US, and the second nonsensical: at that time Ajzenberg-Selove had just been appointed the first woman officer of the American Physical Society, and had more publication citations than any other member of the department which was considering her application, except one, the Nobel Laureate J. Robert Schrieffer. She initiated a sex-discrimination charge which she eventually won, and was awarded the position (Finkbeiner, 1994).

10. In 2002, women made up 46.1 per cent of the Canadian workforce overall.

In another example, Melissa Franklin, a renowned physicist based at Harvard University and Harvard's first female tenured physicist, is recognized as a key contributor to the discovery of the top quark. However, her aggressiveness – a character trait that men are encouraged to develop in their professional life – held back her early career progress. A Canadian citizen, in 1989 her attempts to secure government funding for a research project were unsuccessful because she was characterized as 'a very obnoxious person' by the Minister of State for Science and Technology. This was when she had 'forcefully' told him that her work deserved ample funding. Later, when she took a position as Associate Professor at Harvard because she was unable to secure sufficient funding in Canada for her work, she was told by a male member of the physics department that she was a second-rate researcher (Nichols, 1992).

In addition to situations of individual, informal and personalized sexism, it has been found that in general the academic culture values men's work over women's. In one study, both men and women were given a research article by an author identified variously as John T. McKay, Joan T. McKay, J. T. McKay (as sex-neutral), Chris T. McKay (ambiguous with respect to sex) and Anonymous. The articles were identical except for the author's name. When identified as written by a male author – John – the article received the highest reviews. Next in ranking was the article identified as written by 'J. T.', and third, 'Joan.' When readers thought the initials 'J. T.' indicated a woman trying to hide her identity, the article was ranked lower (Schiebinger, 1999). In a study that analysed acceptance rates of articles submitted to economics journals, Ferber and Teinman (1980) found that when referees are blind to sex, articles submitted by women either alone or with a male co-author have a significantly higher acceptance rate than articles submitted by men; when sex is known or inferred, acceptance rates are equal.

Other indications include the fact that men work at prestigious universities more often than women, and a study in Sweden found that women need to publish three times as many papers to be ranked equally with their male colleagues. The experience of Faye Ajzenberg-Selove corroborates this finding. The NSF review (2004) found that women receive less credit for experience than men, partly due to family responsibilities and workforce interruptions, but also due to gender bias. The MIT study found that the marginalization women felt in their careers were accompanied by differences in salary, space, awards, resources and response to outside offers, with women receiving less of all these resources, even though their professional accomplishments were equal to those of their male counterparts (MIT, 1999). 'Whatever their productivity, women's achievements are not equally rewarded by salary increases, promotion, or professional recognition' (Schiebinger, 1999, p. 48).

S&T for social development: Meeting the needs of society

It is important to recognize that women deal with S&T in their daily lives in a way that, although experiential and non-formal, is nonetheless based in scientific and technological knowledge and practice. This is an area of S&T that has been largely ignored.

Research and analysis on the implementation of technology for development over twenty to thirty years has found that gender biases exist in determining who receives technologies and who receives the training, credit and other resources necessary to benefit from their use. These decisions are influenced by a number of assumptions. They include a tendency of governments and development agencies to treat technology as a neutral, value-free tool, without taking into account the social, environmental and economic effects of the technology being introduced. Additionally, the assumption is often made that adoption of technologies naturally leads to development, while women's technological skills and use of technologies are often overlooked. Finally, research has demonstrated that women do not have equal access to development resources – including credit, training and information.[11]

UNCSTD's Gender Working Group found in 1995 that, as a result of these gendered perceptions, women's overall position has actually declined relative to men after decades of S&T interventions in development, and women have become disproportionately poor in relation to the men in their communities (Gender Working Group, 1995).

Women's STA in their daily work is overlooked:

- Women engage in 60–90 per cent of agricultural production activities in the developing world.

11. Blackden and Banu, 1999; Stamp, 1991.

- Women tend to be responsible for the gathering and use of energy for cooking, as well as for water and sanitation needs in their communities.
- They are holders of much of the world's indigenous knowledge about medicinal and agricultural uses and processing of plants and seeds.
- They are providers of family healthcare.
- Women make up two-thirds of non-formal sector producers and traders.

Local knowledge is one area in which women's S&T knowledge and practices are critical for ecologically sustainable development. Like other scientific systems, local knowledge systems develop technology and management practices to improve the quality of life of people. Because the primary social differentiation among adult, economically active members of a society is based on gender, specific areas of activity become the domains of different genders as they increase their knowledge and skill over time.

As a result, local knowledge and skills possessed by women often differ from those held by men. For example, in certain parts of the Andes, women have more knowledge of livestock management practices than men, whereas men know more about soil classification. Although women's indigenous knowledge of environmental management has been marginalized by the Eurocentrism and gender bias of S&T, men's traditional environmental knowledge has frequently been wiped out completely. In many communities in developing countries, women are the primary holders of indigenous knowledge and know-how about sustainable environmental use and management, and their knowledge often underpins family survival strategies in periods of stress (ITDG, 2000). In parts of Mali, it was found that women cultivated thirty traditional varieties of plants while men did not cultivate any, whereas men cultivated three out of four modern varieties and women only one (Huvio and Synnevåg, 1999).

As a result of these and other activities engaged in by women, it has been found that societies that discriminate by gender pay a high price in their ability to develop and to reduce poverty and that eradicating poverty depends on improving the situation of women and increasing the efficiency of their work. A World Bank Policy Research Report (King and Mason, 2001) shows that eradicating poverty depends on improving the situation of women and increasing the efficiency of their work, and that countries with smaller gaps between women and men in areas such as education, employment, and property rights not only have lower child malnutrition and mortality, they also have more transparent business and government and faster economic growth, which in turn helps to further narrow the gender gap'. Conversely, 'reducing the gender gap in health and education reduces individual poverty and encourages economic growth' (UNFPA, 2002), and when technologies improve women's production and increase income, children's well-being improves, school enrolment rises, birth rates decrease and environmental conservation increases.

We also know from research on the introduction of agricultural technologies that women experience empowerment from use of the technologies. Poor women involved in a fishpond development in Bangladesh experienced greater mobility, greater likelihood of working for pay, higher off-farm incomes, and better nutritional status than their counterparts. Women cultivating improved vegetables in Bangladesh reported empowerment in dealing with traders and their husbands, increased freedom of movement, freedom from physical violence, and political knowledge and awareness specifically related to the adoption of the technology and not just resulting from membership in the NGO (which also contributed to empowerment). It is well documented that when women earn higher incomes as a result of improved technology or techniques, they gain higher status in the home and community, children are educated, and nutrition levels increase for both males and females in the family (Meinzen-Dick et al., 2004).[12]

For these reasons, empowering women's use of and benefit from the application of S&T for development will see extended benefits to a broader range of social groups, and will have a direct impact on society as a whole. In most countries women make up a substantial portion of the lowest income groups, and in most regions they make up the majority of the rural population.

Women's roles as scientific innovators and technologists should not be overlooked. In fulfilling their day-to-day responsibilities, they demonstrate technological knowledge and creativity that has been overlooked by 'mainstream'

12. See Huyer, 2004, for a discussion of six areas identified as critical for women's abilities, perspectives and production to be considered in design, development and application of S&T: agriculture and food security, energy, water and sanitation, biotechnology, and ICTs.

BOX 2.3: FROM PIGS TO POLITICS IN THE PHILIPPINES

With a small initial investment, the Canadian International Development Agency (CIDA) has managed to help bring prosperity, independence and a political voice to thousands of Filipino women. In 1989/90, a CIDA project lent $9,000 to twenty-five women in San Miguel Bulacan, to breed and fatten pigs for sale. Half of the money from each pig sold went into a 'piggy bank' of co-operative savings. Within four years, the women had repaid the initial loan, built better houses, bought new vehicles for their family enterprises, and sent their children to university for the first time ever.

With the funds and experience they had gained, the women started a knitting co-operative and sub-contracted 800 village women to produce garments. Soon they were exporting hundreds of thousands of stuffed toys to North America, and needed professional sewing machines to meet the demand. They built two factories with funding from the UN, which they quickly repaid. Through the production process, the women taught themselves to manage their factories and train staff. They used their profits to start a fruit-growing co-operative, and now own half a million mango and guava trees.

The San Miguel Women's Association grew to 100,000 members in 49 villages. In the 1992 local elections, 80 women candidates were fielded, and 38 won. One hundred women ran in the 1997 village elections, and 45 won. Many candidates are now looking to enter national politics.

Source: CIDA, 1999.

BOX 2.4: DO-IT-HERSELF PROJECT, INTERMEDIATE TECHNOLOGY DEVELOPMENT GROUP

The Do-It-Herself Project operates on the assumption that women as technology users have specialized technical knowledge that they employ daily in the operation of production processes, and that they use their knowledge and skills to develop, modify and adapt the techniques and technical processes in which they are involved.
It defines technology as:

- hardware (machinery or equipment) of production
- software (knowledge or skills) needed to produce something, including the concepts and thinking processes linked to production
- the organization needed both to produce a product and to enable production to take place, including social organization
- the product itself.

Innovation is defined as any change, however small, in the skills, techniques, processes, equipment type or organization of production, that enables people to better cope with or take advantage of production, or take advantage of particular circumstances.

Source: Appleton, 1995.

development. Women innovators and scientists in the Philippines have developed inventions and processes to help women in their daily tasks, including a portable lightweight power tiller and a process that gives coconut milk (a staple of the Philippine diet) a shelf-life of twelve months (Moussa, 1995).

International policy on gender and SET

There is already a long a history of international analysis and action on gender issues in S&T. Since 1975, many international conferences have addressed these issues. These include the Vienna Programme of Action on Science and Technology for Development (1979), the UN Panel of the Advisory Committee on Science and Technology for Development (1984), the 1985 and 1995 World Conferences on Women, and, more recently, Beijing +10, the World Summit on Sustainable Development (2002), the World Conference on Science (1999), and the World Summit on the Information Society (2003).

These conferences have addressed gender and S&T as they cut across a range of sectors, including health, energy, agriculture, the environment, education, information systems and micro-enterprises. Other recommendations call upon governments to increase opportunities for women to participate in education and careers in S&T, and set out strategies to ensure fuller participation of women in policy- and decision-making bodies.

On a parallel and often intersecting track, the numbers of international and national networks, professional associations and NGOs promoting and advocating for recognition of women's contributions to S&T have increased dramatically in the last ten years, as have national-level mechanisms, networks and initiatives to recognize and mobilize women's capacities for national development.[13]

Repeatedly, issues of access to resources, information and relevant skills training appear in documents from these international fora. More recently, issues around local knowledge systems and the differential impact of S&T on the lives of women and men have emerged.

The *Platform for Action* of the Fourth World Conference on Women (DAW, 1995) made a series of recommendations on gender and S&T concerning:

- access to technologies, information and technical assistance (for women entrepreneurs, farmers and fisheries producers)
- access to science education and technical training
- access to non-traditional employment
- gender sensitive health research
- recognition of women's indigenous knowledge
- strengthening the position of women scientists and technologists
- reducing excessive military expenditures (implicitly including military research)
- the impact and potential of new technologies
- women's role in natural resource management and the impact of environmental degradation on women's lives
- gender sensitive policy-making, planning and programming
- participation in decision- and policy-making.

The 1999 World Conference on Science ratified a *Framework for Action*, Paragraph 90 of which reads:

> special efforts should be made by governments, educational institutions, scientific communities, non-governmental organizations and civil society, with support from bilateral and international agencies, to ensure the full participation of women and girls in all aspects of science and technology, and to this effect to:
>
> - promote within the education system the access of girls and women to scientific education at all levels
> - improve conditions for recruitment, retention and advancement in all fields of research
> - launch, in collaboration with UNESCO and the United Nations Development Fund for Women (UNIFEM), national, regional and global campaigns to raise awareness of the contribution of women to science and technology, in order to overcome existing gender stereotypes among scientists, policy-makers and the community at large
> - undertake research, supported by the collection and analysis of gender-disaggregated data, documenting constraints and progress in expanding the role of women in science and technology
> - monitor the implementation of and document best practices and lessons learned through impact assessment and evaluations

13. See www.wigsat.org, www.sarg.org.za, and www.unece.org/stats/gender/web/links.htm for examples and links to organizations and initiatives at international and national levels. See also the Annex for a list of related initiatives and organizations.

- ensure an appropriate representation of women in national, regional and international policy- and decision-making bodies and forums
- establish an international network of women scientists
- continue to document the contributions of women in science and technology.

To sustain these initiatives governments should create appropriate mechanisms, where these do not yet exist, to propose and monitor introduction of the necessary policy changes in support of the attainment of these goals.

UNCSTD's Gender Working Group was formed in 1993 to make recommendations to national governments for individual country actions and recommendations to the Economic and Social Council (ECOSOC) for UN reforms on gender and S&T. The key findings of this report, which was subsequently ratified and accepted by UNCSTD and ECOSOC, concern:

- **Gender inequity in education and careers in S&T**. There are serious obstacles to girls' and women's participation in scientific and technical education and careers, and there are relatively few women in S&T decision-making bodies and advisory boards.
- **The gender-specific nature of technical change**. Technical change aimed at benefiting people in rural areas in developing countries appears to have benefited men more than women.

The Gender Working Group specifically recognized that development is gender specific, that is, that women and men have different roles and responsibilities in society. Therefore, to ensure that S&T benefit all members of society, the Group called for purposeful and equitable policy attention to the respective needs and interests of men and women.

It identified seven issues in which 'transformative actions' are both necessary and feasible:

1. achieving gender equity in S&T education
2. removing obstacles to women in S&T careers
3. making science responsive to the needs of society: The gender dimension
4. making the S&T decision-making process more 'gender aware'
5. relating better with 'local knowledge systems'
6. addressing ethical issues in S&T: The gender dimension

BOX 2.5: A *DECLARATION OF INTENT* ON GENDER, SCIENCE AND TECHNOLOGY FOR SUSTAINABLE HUMAN DEVELOPMENT

All governments agree to work actively toward the following goals:

1) To ensure basic education for all, with particular emphasis on scientific and technological literacy, so that all women and men can effectively use science and technology to meet basic needs.
2) To ensure that men and women have equal opportunity to acquire advanced training in science and technology and to pursue careers as technologists, scientists and engineers.
3) To achieve gender equity within science and technology institutions, including policy- and decision-making bodies.
4) To ensure that the needs and aspirations of women and men are equally taken into account in the setting of research priorities and in the design, transfer and application of new technologies.
5) To ensure all men and women have equal access to the information and knowledge, particularly scientific and technological knowledge, that they need to improve their standard of living and quality of life.
6) To recognize local knowledge systems, where they exist, and their gendered nature as a source of knowledge complementary to modern science and technology and also valuable for sustainable human development.

Source: GAB-UNCSTD, 1995.

As part of its mandate the GWG undertook a review of the performance of the UN agencies with respect to gender, science and technology. UNIFEM subsequently released a report, *Review of UN Agency Activities in the Field of Gender, Science and Technology*, which was updated in 1998.

See also the Gender Advisory Board website: http://gab.wigsat.org.

7. improving the collection of gender-disaggregated data for policy-makers.

It also invited governments to subscribe to a *Declaration of Intent* (see Box 2.5) and set up national ad hoc committees to formulate national action plans for implementing the declaration.

Chapter 3

Measuring science and technology activities: Principal international guidelines

Introduction

The next two chapters will summarize international methods for measuring S&T activities (STA), personnel (STP), qualifications and occupations. The various approaches will be assessed in terms of the kinds of information they provide and how they can be disaggregated by sex, age and other variables. Questions to be addressed include the definition of a range of activities in the economy – or sectors of employment – that can be considered to constitute or incorporate STA.[1]

This chapter will discuss STA in technical detail and review the principal lists used to classify STA and STP. They include 'fields of study' – employed in regular education statistics; or 'fields of science (disciplines)' – which serve other classification purposes (recently, the expressions 'fields of education and training' have also been introduced). The STA sub-groups, as well as a number of other related concepts and classifications, will also be presented.

In Chapter 4, the measurement of STP will be addressed by drawing on both educational and occupational criteria. Several variables of interest for measuring the 'stocks' and the 'flows' of HRST will also be presented.

S&T: Definitions and conceptual approach

S&T is a broad and, at times, vague concept. That is, it is not necessarily perceived in the same way everywhere and by everyone. The perception may vary according to purpose: for example, the goal of identifying which programmes or disciplines have the highest enrolment rates is different from that of classifying an S&T/R&D project for policy or statistical purposes, or identifying the persons participating in a particular programme.

Cultural differences also affect perceptions of S&T. In many instances, S&T is understood to cover only the natural sciences and engineering (NSE) but not the social sciences and humanities (SSH). In certain approaches, connections between social and natural sciences are made, for example in global development discourse. An intermediate approach is adopted in the reports of the NSF, whose definition of science and engineering includes some social sciences but excludes the humanities.

Since the purpose of this toolkit is to develop a framework for collecting statistics and disaggregating gender indicators in SET in general, the NSE will be emphasized over SSH. But, depending on whether we are examining the activities and the work force according to occupation or education/qualification, it will at times be necessary to take into account both NSE and SSH. For example, most persons trained in NSE are likely also to find NSE-related jobs, but not all. Some NSE-trained persons will prefer other activities with no direct link at all to their formal training, including working in jobs typically classified as SSH. At the same time,

1. See Chapter 1 for UNESCO's definition of STA.

some persons engaged in NSE activities will not possess a formal NSE background.

To sort out these issues, we need a standard conceptual framework for defining S&T in general, and a relevant classification of education, activities and persons in particular. This list should be sufficiently detailed to allow the identification of specific fields of qualifications, with a view either to analysing them separately or to eliminating certain classifications or information for analytical purposes.

The discussion will begin with a review of the types of STA generally covered in statistical approaches as defined in the UNESCO, OECD and OECD/Eurostat guidelines.

In 1978 UNESCO published a global conceptual and statistical framework for the measurement of STA and STP. These basic definitions, issued in the *Recommendation Concerning the International Standardization of Statistics on Science and Technology* (referred to below as the *Recommendation*) became the mandate for the collection of S&T and R&D statistics at UNESCO. Later, UNESCO issued, to a limited audience of producers and users of S&T data, some further practical guidelines in a *Manual for Statistics and Technological Activities* (1984). Much of the original content of the *Recommendation* is now out of date, but it has not been revised or updated, and UNESCO has now generally adopted the OECD *Frascati Manual* guidelines for its own R&D (rather than S&T) data collection. For further technical guidelines, users are invited to consult the guiding principles in the UNESCO questionnaires for its regular international R&D and education surveys.

The guidelines sketched below will also draw on methodological work of the OECD and Eurostat, the Statistical Office of the EC. In cases of discrepancy between the guidelines of the three agencies, preference will be given to those recommendations that have proved to be most useful from an operational perspective. Reference will also frequently be made to education statistics currently collected in a common UNESCO/OECD/Eurostat (UOE) questionnaire.

This chapter will then turn to a framework that allows classification of education, activities and people – the *International Standard Classification of Education* (ISCED). ISCED was first issued by UNESCO in 1976 and then revised in 1997 (in close cooperation with the other international agencies). Both versions present lists of levels of education, with the highest levels referring to tertiary (or higher) education, and detailed lists of fields or disciplines.

The introduction of ISCED-97 resulted in a break in the statistical time series from 1998 onwards. However, from the perspective of sex-disaggregated statistics, this was not a dramatic change, since, prior to the end of the 1990s, sex-disaggregated statistics were collected only sporadically. The first version of the present toolkit was issued at the threshold between the 1976 and the 1997 ISCED versions and therefore paid much attention to the comparison between the two. ISCED-76 should not be ignored however since it continues to serve as a basic reference for other international classifications, such as ISCO and the *Canberra* and *Frascati Manuals* (see below), in discussions of, for instance, levels of education and fields of science.

Science and technology activities (STA)

According to the UNESCO *Recommendation*, STA consist of the following three broad groups, each of which is presented in more detail below:

- research and (experimental) development (R&D)
- scientific and technical education and training (STET) at broadly the tertiary level
- scientific and technological services (STS).

Each of these groups has relevance to this toolkit, especially pertaining to the sectors of employment of STP. R&D data and education statistics for the university sector are those most commonly collected; they are also those for which the best degree of international comparability has been achieved so far.

Research and (experimental) development (R&D)

UNESCO, OECD and Eurostat currently use a broad common definition of R&D to measure both expenditures and personnel. Detailed technical guidelines for the measurement of R&D resources are found in the OECD *Frascati Manual*. R&D is defined in the *Manual* as:

> creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (OECD, 2002, p. 63).

R&D covers both formal R&D in special R&D units and informal or occasional R&D in other units (p. 64).

The *Recommendation* suggests that the category of 'Research activities' be split into two broad groups: on the one hand, R&D in the natural sciences, technology, medical and agricultural sciences (commonly described as NSE), and, on the other, R&D in SSH. Issues of classification by ISCED fields of science/fields of study will be discussed in more detail below.

It is further suggested that R&D be sub-divided by type of activity. This breakdown is generally used for R&D expenditures rather than for R&D personnel:

- fundamental research
- applied research
- experimental development.

Fundamental research, frequently also referred to as 'basic research', is defined as 'experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view' (p. 240).

Applied research is 'also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective' (p. 245).

Experimental development is defined as 'systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services, or to improving substantially those already produced or installed' (p. 249).

These three categories are theoretical and subjective. They describe, in an over-simplified way, the R&D process as a more-or-less linear course of action, passing from original basic research to a stage of applied research, followed by a stage of experimental development resulting in a new product or a new process. The reality of R&D is, of course, more complex.

This terminology is, nevertheless, frequently used in R&D/S&T policy discussions of questions, such as, 'does this country invest enough in basic research?' Or 'should universities engage solely in fundamental research or should they also invest in applied research, or even in development?' It is not easy to support such discussions with solid data, for no statistical cross-classifications are available at the international level between the 'type of activity' series and, for instance, sources of finance or types of R&D personnel.

A certain number of criteria and examples for distinguishing between the three types of R&D, preferably at the project level, are provided in the *Frascati Manual*. The breakdown is usually easier to apply to R&D in NSE than to the social sciences and, notably, to the humanities (SSH).

The following examples are from the *Frascati Manual* (OECD, 2002):

Natural sciences and engineering: The determination of the amino acid sequence of an antibody molecule is basic research. Investigations undertaken in an effort to distinguish between antibodies of various diseases is applied research. Experimental development then consists of devising a method for synthesizing the antibody for a particular disease on the basis of knowledge of its structure, and clinically testing the effectiveness of the synthesized antibody on patients who have agreed to accept experimental advance treatment (Para. 253).

Social sciences: Analysis of the environmental determinants of learning ability is basic research. Analysis of the environmental determinants of learning ability for the purpose of evaluating education programmes designed to compensate for environmental handicaps is applied research. The development of the means of determining which educational programme to use for particular classes of children is experimental development (Para. 254).

Scientific and technical education and training (STET) at broadly the tertiary level

UNESCO defines this category as

> all activities comprizing specialized non-university higher education and training, higher education and training leading to a university degree, post-graduate and further training, and organized life-long training for scientists and engineers. These activities broadly correspond to ISCED Levels 5, 6 and 7.[2]

2. This reference goes back to the 1976 version of ISCED. It should now normally be understood as a reference to the new levels 5–6 of ISCED-97.

Sex-disaggregated statistics of specific interest pertaining to scientific and technical education and training (STET) include numbers of students engaged in or graduating from higher education, as well as data on teaching staff. There is currently little sex-disaggregated data available on training and retraining statistics, but in view of rapid technological developments and subsequent needs for lifelong learning, this is one of the areas where sex-disaggregated information and statistics would be of particular interest to policy-makers.

Scientific and technological services (STS)

This is the broadest of the STA classes. STS are defined by UNESCO as 'activities concerned with research and experimental development and contributing to the generation, dissemination and application of scientific and technical knowledge'. Nine STS categories are suggested in the *Recommendation,* specified below. Note that this list was developed in the 1970s and does not really reflect recent developments in S&T, such as space activities, information and communications technologies, biotechnologies, nanotechnologies and other innovative high-tech areas. The nine classes originally proposed were:

i) STS provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information processing departments.
ii) STS provided by museums of science and/or technology, botanical and zoological gardens, and other S&T collections (anthropological, archaeological, geological, etc.).
iii) Systematic work on the translation and editing of S&T books and periodicals (with the exception of textbooks for school and university courses).
iv) Topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations; surveying of soils and of plants; fish and wildlife resources; routine soil, atmosphere and water testing; routine checking and monitoring of radioactivity levels.
v) Prospecting and related activities designed to locate and identify oil and mineral resources.
vi) The gathering of information on human, social, economic and cultural phenomena usually for the purpose of compiling routine statistics, such as population censuses; production, distribution and consumption statistics; market studies, social and cultural statistics.
vii) Testing, standardization, metrology and quality control; routine analysis, checking and testing, by recognized methods, of materials, products, devices and processes, together with the setting up and maintenance of standards and standards of measurement.
viii) Routine counselling of clients, other sections of an organization or independent users, designed to help them to make use of scientific, technological and management information. This activity also includes extension and advisory services organized by the state for farmers and for industry but it does not include the normal activities of project planning or engineering offices.
ix) Activities relating to patents and licences; systematic work of a scientific, legal or administrative nature on patents and licences carried out by public bodies.

These groups should preferably be seen as sectors of employment. It is difficult, however, to cross-classify such STS by occupations/professions, and even more so by educational qualifications in terms of field of study of the persons involved. However, breakdowns by sex should be possible.

S&T as levels of study (education)/ fields of science

The International Standard Classification of Education (ISCED)

ISCED – Developments since 1976

The United Nations/UNESCO *International Standard Classification of Education* (ISCED 1976) is the classification most commonly used at both international and national levels for the measurement of STA and STP. Most country-specific lists of fields of study and other education statistics are directly linked to the 1976 and/or the revised 1997 version. Both focus on the classification

of education programmes by level and field of education, and also touch upon possible cross-classifications between the two variables.[3]

The purpose of ISCED-97 is to 'serve as an instrument suitable for assembling, compiling and presenting comparable indicators and statistics of education both within individual countries and internationally. It presents standard concepts, definitions and classifications'. Furthermore, 'it can be utilized for statistics on many different aspects of education such as statistics on pupil enrolment, on human or financial resources invested in education or on the educational attainment of the population' (UIS, 1997).

ISCED-97 is intended to take into account recent developments in national and international education systems, such as the multiplication of new types of vocational education and training programmes, increasing diversity of education providers, and new types of distance education based on new technologies. The 1997 revision differs from ISCED-76 regarding, among other things, general terminology, definitions, renumbering of levels, new rules and criteria for the allocation of programmes to levels, and new specifications in the classification list.

One of the principal new elements of relevance to gender and S&T issues in ISCED-97 is the introduction of research qualifications as a new concept at the highest levels of tertiary (higher) education (Level 6). This information was not directly available in ISCED-76. The main criterion for this level is that it 'typically requires the submission of a thesis or dissertation of publishable quality which is the product of original research and represents a significant contribution to knowledge'. A subsidiary criterion is that 'it prepares graduates for faculty posts in institutions offering ISCED level programmes, as well as research posts in government, industry, etc.'

There are still large variations between the ways in which education systems are organized in different countries. This also refers to the ways different types of education programmes are classified by level. One example of particular relevance to gender-related S&T policies: in some countries, programmes for the training of nurses (in separate institutions or in hospitals, for instance) are considered as third-level (higher education), whereas in others this training would be classified at a lower ISCED level.

ISCED-76 had suggested a detailed list of some twenty one fields of study (also described as 'subject matter content of study'). In the 1997 terminology, the wording 'fields of study' is changed to 'fields of education', with twenty five fields in total. The educational programme remains the basic unit of classification in ISCED. These ISCED files are commonly used also as fields of science lists for the classification of STA other than education, such as academic research and bibliometrics (the registration and analysis of publications and citation counts).

Several sets of practical guidelines for the application of ISCED-97 have been issued. In June 1999, the UIS published the *Operational Manual for ISCED-1997,* which deals with the classification of programmes by levels, and was intended to 'facilitate the application of ISCED-1997 to national programmes of education in establishing appropriate ISCED mapping'. The same year the OECD published its handbook *Classifying Educational Programmes – Manual for ISCED-97 Implementation in OECD Countries,* and Eurostat – in cooperation with the European Centre for the Development of Vocational Training (CEDEFOP) – issued a manual on fields of education and training.

The new ISCED–97 levels

The revised levels are in several important respects different from those outlined in ISCED-76. This is illustrated in the matrix below (Figure 3.1).

The total number of persons in the population who may be available for advanced S&T work in the shorter term accords to ISCED-97 Levels 4 and above. This category includes both those already engaged in STA and those currently out of the work force but who in the past have acquired formal competence in S&T. This is the approach recommended in the OECD/Eurostat *Canberra Manual* (see Chapter 4) on the measurement of total stocks and flows of STP. If, on the other hand, the goal is to gain a longer-term increase of participation in S&T by younger people in general and by young women in particular, then it may be of value to begin by monitoring trends at the lower ISCED levels.

3. ISCED exists in all of the official languages of UNESCO (English, French, Spanish, Russian, Arabic, Chinese). It can be downloaded for free in PDF format from the UIS website, www.uis.unesco.org.

Figure 3.1: ISCED-1976 compared to ISCED-1997 (Levels)

<table>
<tr><th></th><th>ISCED-1976</th><th></th><th>ISCED-1997</th></tr>
<tr><td>0</td><td>Education preceding the first level</td><td>0</td><td>Pre-primary education</td></tr>
<tr><td>1</td><td>Education at the first level</td><td>1</td><td>Primary education or first stage of basic education</td></tr>
<tr><td>2</td><td>Education at the second level, first stage</td><td>2</td><td>Lower secondary or second stage of basic education</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Education at the second level, second stage</td><td>3</td><td>Upper secondary education</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Post-secondary non-tertiary education</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Education at the third level, first stage, of the type that leads to an award not equivalent to a first university degree</td></tr>
<tr><td rowspan="3">5</td><td rowspan="3">First stage of tertiary education (not leading directly to an advanced research qualification)

5A) largely theoretically-based/research preparatory programmes

5B) practical/technical/occupationally specific programmes</td></tr>
<tr><td>6</td><td>Education at the third level, first stage, of the type that leads to a first university degree or equivalent</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Education at the third level, second stage of the type that leads to a post-graduate university degree or equivalent</td></tr>
<tr><td>6</td><td>Second stage of tertiary education (leading to an advanced research qualification)</td></tr>
<tr><td>9</td><td>Education not definable by level</td><td></td><td></td></tr>
</table>

Note: In ISCED-76 the level code numbers 4 and 8 were not attributed. In ISCED-97 a new Level 4 was introduced (to cover programmes straddling the boundary between upper-secondary and post-secondary education from an international point of view). Tertiary education in ISCED-97 now only comprizes two levels, Levels 5 or 6, instead of the previous three ISCED-76 Levels 5 to 7. Furthermore, the former ISCED-76 Level 9, 'Education not definable by level' has been suppressed in ISCED-97. *Source*: UIS, 1999.

The ISCED lists of fields of study and fields of education

Compared to ISCED-76, the ISCED-97 list of fields has been modified to eliminate overlaps and include new fields. Another innovation is the establishment of broad functional groups composed of fields having similarities. One example is the group 'Health and Welfare', which comprizes educational programmes in medicine, medical services, nursing, dental services and social services.

The ISCED-97 list 'Broad groups and fields of education' is shown in Figure 3.2. The list is provisional and in need of work to clarify areas of confusion between, for instance, programmes or functions and professional categories.

From the statistical and S&T policy perspectives, detailed breakdowns by fields of study (as well as related fields of science) may be of great interest at the national level, but they are seldom applicable for international comparisons. In R&D surveys, including those by OECD, UNESCO and Eurostat, use is made only of the broad NSE and SSH fields of science as a rule, as breakdowns primarily for the higher education, private non-profit and (parts of) public sectors defined by the *Frascati Manual* (see Chapter 4). A number of countries are not yet in a position to supply even this aggregated information.

Figure 3.2: ISCED-97 structure by broad groups of fields of education and programmes

General programmes

01 Basic programmes
Basic general programmes pre-primary, elementary, primary, secondary, etc.

08 Literacy and numeracy
Simple and functional literacy, numeracy.

09 Personal development
Enhancing personal skills, e.g. behavioural capacities, mental skills, personal organizational capacities, life orientation programmes.

Education

14 Teacher training and education science
Teacher training for pre-school, kindergarten, elementary school, vocational, practical, non-vocational subjects, adult education, teacher trainers and handicapped children. General and specialized teacher training programmes. Education science: curriculum development in non-vocational and vocational subjects. Educational assessment, testing and measurement, educational research, other education science.

Humanities and arts

21 Arts
Fine arts: drawing, painting, sculpture; performing arts: music, drama, dance, circus; graphic and audio-visual arts: photography, cinematography, music production; radio and TV production, printing and publishing; design; craft skills.

22 Humanities
Religion and theology; foreign languages and cultures; living or dead languages and their literature, area studies; native languages: current or vernacular language and its literature; other humanities: interpretation and translation, linguistics, comparative literature, history, archaeology, philosophy, ethics.

Social sciences, business and law

31 Social and behavioural science
Economics, economic history, political science, sociology, demography, anthropology (except physical anthropology), ethnology, futurology, psychology, geography (except physical geography), peace and conflict studies, human rights.

32 Journalism and information
Journalism, library technician and science, technicians in museums and similar repositories; archival sciences.

34 Business and administration
Retailing, marketing, sales, public relations, real estate; finance, banking insurance, investment analysis; accounting, auditing, bookkeeping; management, public administration, institutional administration, personnel administration; secretarial and office work.

38 Law
Local magistrates, 'notaires', law (general, international, labour, maritime, etc.), jurisprudence, history of law.

Science

42 Life sciences
Biology, botany, bacteriology, toxicology, microbiology, zoology, entomology, ornithology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences.

44 Physical sciences
Astronomy and space sciences, physics, other allied subjects, chemistry, other allied subjects, geology, geophysics, mineralogy, physical anthropology, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, marine science, vulcanology, palaeoecology.

46 Mathematics and statistics
Mathematics, operations research, numerical analysis, actuarial science, statistics and other allied fields.

48 Computing
Computer sciences, system design, computer programming, data processing, networks, operating systems – software development only (hardware development should be classified within the engineering fields).

Engineering, manufacturing and construction

52 Engineering and engineering trades
Engineering drawing, mechanics, metal work, electricity, electronics, telecommunications; energy and chemical engineering, vehicle maintenance, surveying.

(Continued)

54 Manufacturing and processing
Food and drink processing, textiles, clothes, footwear, leather, materials (wood, paper, plastic, glass, etc.), mining and extraction.

58 Architecture and building
Architecture and town planning, structural architecture, landscape architecture, community planning; cartography; building construction; civil engineering.

Agriculture

62 Agriculture, forestry and fishery
Agriculture, crop and livestock production, agronomy, animal husbandry, horticulture and gardening, forestry and forest product techniques, natural parks, wildlife, fisheries, fishery science and technology.

64 Veterinary
Veterinary medicine, veterinary assisting.

Health and welfare

72 Health
Medicine: anatomy, epidemiology, cytology, physiology, immunology and immunoaematology, pathology, anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, neurology, psychiatry, radiology, ophthalmology. Medical services: public health services, hygiene, pharmacy, pharmacology, therapeutics, rehabilitation, prosthetics, optometry, nutrition; nursing; basic nursing, midwifery; dental services: dental assisting, dental hygienist, dental laboratory technician, odontology.

Social services
Social care: care of the disabled, child care, youth services, gerontology services; social work: counselling, welfare.

Services

81 Personal services
Hotel and catering, travel and tourism, sports and leisure, hairdressing, beauty treatment and other personal services, cleaning, laundry, dry-cleaning, cosmetic services, domestic science.

84 Transport services
Seamanship, ship's officer, nautical science, air crew, air traffic control, railway operations, road motor vehicle operations, postal service.

85 Environmental protection
Environmental conservation, control and protection, air and water pollution control, labour protection and security.

86 Security services
Protection of property and persons: police work and related law enforcement, criminology, fire-protection and fire-fighting, civil security; military.

Not known or unspecified

99 This category is not part of the classification itself, but in data collection it is needed for 'fields of education not known or unspecified'.

Source: ISCED, 1997.

Figure 3.3: Current OECD list of broad fields of S&T and their sub-categories, as recommended by the Frascati Manual 2002 for the purpose of R&D surveys (list originally based on the ISCED-76 classification).

Natural sciences

1.1 Mathematics and computer sciences (mathematics and other allied fields: computer sciences and other allied subjects [software development only; hardware development should be classified in the engineering fields]).

1.2 Physical sciences (astronomy and space sciences, physics and allied subjects).

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology and allied sciences).

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics and allied sciences, excluding clinical and veterinary sciences).

Engineering and technology

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and allied subjects).

2.2 Electrical engineering, electronics (electrical engineering, electronics, communication engineering and systems, computer engineering [hardware only] and allied subjects).

2.3 Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialized subdivisions; forest products, applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialized technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and allied subjects).

Medical sciences

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immuno-haematology, clinical chemistry, clinical microbiology, pathology).

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, othorhinolaryngology, ophthalmology).

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology).

Agricultural sciences

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture and allied subjects).

4.2 Veterinary medicine.

Social sciences

5.1 Psychology.

5.2 Economics.

5.3 Educational sciences (education and training and allied subjects).

5.4 Other social sciences (anthropology, social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organization and methods, miscellaneous social sciences and interdisciplinary, methodological and historical STA relating to subjects in this group (physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences).

Humanities

6.1 History (history, prehistory and history, together with auxiliary historical disciplines, such as archaeology, numismatics, palaeography, genealogy).

6.2 Languages and literature (ancient and modern languages and literatures).

6.3 Other humanities (philosophy [including the history of science and technology], arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic research of any kind, religion; theology, other fields and subjects pertaining to the humanities, methodological historical and other STA relating to the subjects in this group).

Source: OECD, 2002.

Chapter 4

Science and technology personnel – Measurements and classifications

Introduction

This chapter uses the same technical rules as Chapter 3 for definitions and classifications of STA to address the definitions of STP. It will begin by introducing principal international guidelines for the determination of STP. Who is a practitioner of S&T and what are his or her qualifications? Which occupations are included in the definitions of STP? The second section will present methods to measure the activities engaged in by STP. What do they do? How much of their time is taken up with STA? Where are they working, for example in industry, public agencies, universities or other sectors? The concepts and applications of 'Head Count' (HC) versus 'full-time equivalency' (FTE) data will be discussed. The final section will briefly look at other potential variables for disaggregating data in addition to or in conjunction with gender.

Possibilities for and approaches to disaggregating these measurements by sex will be incorporated into the discussion. With the exception of education statistics, systematic collection of sex-disaggregated data was, for many years, comparatively rare in most of the world, although considerable progress has been made. Even where the principal international guidelines suggested that data could be collected or broken down by sex, these recommendations were seldom followed in practice. This was due less to technical difficulties of finding and compiling the data than to a lack of political will.

Most of the principal international agencies are now directly engaged in systematic collection, analysis and diffusion of sex-disaggregated S&T statistics, notably the European Commission/Eurostat, OECD and UNESCO. These recent developments are direct consequences of the agreements reached at a number of United Nations conventions, such as the 1995 World Conference on Women and the World Conference on Science in 1999, on the collection of sex-disaggregated data reflecting women's economic and S&T contributions.

Human resources have always been considered as central to S&T policy. They vary over time, as do possible policy actions to encourage their development. In determining the volume of national STP resources, it is preferable to set a wide definition of STP that is both useful for policy planning and as accurate as possible. Statistics collection should reflect these priorities. Questions to be asked include who in the population has already received the theoretical training usually required to work in S&T. Also of interest are those who are engaged in STA without having received formal training. An important sector consists of those who have been formally trained in S&T but who – for various reasons – have dropped out of the S&T system (the leaky pipeline). Women are highly represented in this latter category. And finally, where can new applicants for training or retraining in S&T be found? For each of these categories, it is important to have as much information as possible on the participation of women.

The dual approach of collecting information on *qualifications* as well as on *occupations* is of increasing S&T policy interest. Previously, in many parts of the world, people with university qualifications were assured of finding jobs as scientists or researchers in the fields in which they were trained. It was also frequently possible for people without such formal education to acquire relevant skills on the job.

That situation has changed dramatically. There are increasing numbers of highly qualified young people who – as a result of labour market pressure – experience unemployment or are forced to accept jobs at lower professional levels, as technicians, secretaries or assistants. Women in both developed and developing countries have a much lower rate of employment in sectors for which they have been educated or trained. Here, too, improved statistics and indicators are essential for policy-makers.

Principal international guidelines for measuring STP

General

The three principal international standards for the measurement of S&T/R&D personnel, the UNESCO *Recommendation*, the OECD *Frascati Manual* and the OECD/Eurostat *Canberra Manual,* are presented here and discussed in their specific policy contexts. They are, however, exclusively devoted to the measurement of people who, in one way or other, are already linked to or engaged in S&T. For identifying 'new' groups of people potentially interested in S&T, such as the younger age groups of both sexes, these standards are of limited use. Various types of education statistics will instead serve as the basic source of that information.

The UNESCO *Recommendation*: Science and technology personnel (STP)

The UNESCO *Recommendation* (1978) constituted one of the first international efforts to measure total numbers of STP in a systematic way. It was an attempt to undertake a general inventory of available S&T resources in the global economy. However, due to problems essentially of definition – notably the confusion between educational and occupational criteria – such an inventory proved to be difficult to complete in practice.

OECD *Frascati Manual*: R&D personnel

From its inception, the *Frascati Manual* (first issued in 1962) has reflected an OECD emphasis on measuring the human resources (besides expenditures) devoted to R&D only. At the time of the first edition of the *Manual*, development of R&D capacity was considered in the leading economies to be one of the principal objectives of S&T policy. The 'big science' programmes in the postwar period, such as defence, space, and (military and civil) nuclear and other energy developments, required massive inputs of human resources. As noted earlier, R&D personnel represent a small fraction of the total S&T labour force (however defined), but R&D continues to be a political priority in many countries.

The OECD/Eurostat *Canberra Manual:* Human resources devoted to S&T (HRST)

The most recent – and most complete – effort to investigate HRST is contained in the OECD/Eurostat *Canberra Manual* (1994). This manual was produced in direct response to policy needs expressed by the Member States of the two agencies.

During the late 1980s and early 1990s, worries were expressed in a number of Western countries – the United States in particular – that mismatches could occur towards the end of the century between the demand and supply of highly qualified personnel, such as scientists, engineers, IT experts and technicians. Large numbers of those who had been engaged in STA during the war and the first postwar period were reaching the age of retirement. At the same time, national economies were becoming increasingly technology-intensive, requiring greater numbers of qualified STP. The supply of new scientists and engineers was also expected to level-off or even decrease as a result of demographic trends and declining interest in S&T careers among students and graduates. In fact, a number of public opinion surveys at the time indicated that young talented people were more attracted to jobs in sectors such as finance, banking, insurance and real estate.

These concerns appeared to be exaggerated in the end. The expected scarcity of STP was partly offset by immigration of scientists and engineers from the South, increasing absolute numbers of graduate students, and – last but not least – somewhat higher enrolment rates of women in S&T subjects. In the South, related concerns about the brain drain continued to be expressed, as highly qualified persons emigrated to more highly paid and prestigious

positions in developed countries with, at the same time, a tendency for students trained abroad in developed countries not to return home after graduation.

These 'bottleneck' and brain drain discussions have led to the increased awareness of the potential of untapped human S&T resources in general, and women in particular. Attention was turned to those with an S&T background who, for various reasons, had temporarily or permanently left the S&T labour force, but might return to those professions if appropriately motivated. The NSF early on began to chart the involvement of 'hidden reserves' in its annual publication *Women, Minorities and Persons with Disabilities in Science and Engineering*.

These policy debates revealed the need for more pertinent information and data on stocks and flows of STP presented in a well-structured conceptual framework. The result was the *Canberra Manual*, adopted at an OECD conference in Canberra, Australia in 1994. Issued in 1995 – and theoretically very complete – it has, unfortunately, not resulted in the systematic data collection originally expected. This is to some extent due to the use of sample surveys where some variables, such as gender, may be imprecisely defined. Revision work of the *Canberra Manual* is underway (2005), though it is frequently referred to, for instance by Eurostat (see figures in Chapter 5).

Categories of STP

Principal aggregates of STP

Just as it is difficult to define the coverage of S&T, problems are encountered in defining what is meant by 'S&T personnel', or 'STP'.

Many frameworks have been formulated in the debate on stocks and flows of such personnel, each with its own specific coverage and potential utility. The following categories were identified during the preparation of the *Canberra Manual*. All should, depending on the original source of the data, allow a breakdown by sex:

- highly qualified manpower (HQM)
- scientific and technical (or technological) personnel (STP)
- scientific and engineering personnel (SEP)
- scientific, technological and engineering personnel (STEP)
- scientists and technologists
- highly skilled personnel
- qualified scientists and engineers (QSE)
- highly qualified technological manpower (HQTM)
- academic-level researchers and teachers
- research and technological development personnel (RTD)
- research and (experimental) development personnel
- human resources devoted to S&T (HRST).

Each of these broad classes is further divided by a number of variables and subclasses. The principal breakdowns are those by formal education/qualification and by occupation. There are also a number of additional breakdowns, such as detailed occupations, sectors of employment, and labour force status, which will be discussed below. Sex constitutes one of these variables.

Among the above classes, only three appear to be supported by an internationally adopted definition. A definition for 'scientific, technological and engineering personnel (STEP)' had been developed by UNESCO earlier, in the *Recommendation*. OECD proposes a definition of 'research and development (R&D) personnel' in the *Frascati Manual*, and the OECD/Eurostat *Canberra Manual* provides a definition of 'human resources devoted to science and technology (HRST)'. These are discussed in more detail in the next section.

Coverage/definitions of STP

In the UNESCO *Recommendation,* STP are defined as 'the total number of people participating *directly* in STA in an institution or unit and, as a rule, paid for their services. This group should include scientists and engineers and technicians (SET) and auxiliary personnel'.

The OECD *Frascati Manual* defines the initial coverage of global R&D personnel in terms of employment/occupation as 'all persons employed directly on R&D… as well as those providing direct services such as R&D managers, administrators, and clerical staff' (OECD, 2002, p. 294).

The *Canberra Manual* proposes a definition for HRST that more directly combines the two criteria of education/qualification and occupation. HRST are people who fulfil either of the following conditions: (i) 'successfully

completed education at the third level in an S&T field of study'; or (ii) 'not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required'.

The three concepts share a concentration on the most qualified categories of personnel *already engaged* in S&T/R&D. At various levels of sub-classes, both education and occupation criteria are drawn on, which in practice may be difficult to distinguish. For example, the title 'engineer' used in all the above standards may be understood as an indicator either of formal qualification/training or of occupation. With regard both to definitions and coverage, the guidelines are closely linked to the principal international standard classifications: ISCED for education, and the *International Standard Classification of Occupations* (ISCO) for occupation. Both classifications were revised in the late 1980s and the 1990s and further revisions are underway.

The various subclasses by occupation and/or education of the broad STP groups will be discussed in more detail below. The main purpose expressed in these measurement standards (notably the *Canberra Manual*) is to draw on already available statistics without having to embark on completely new data collection exercises. They also all suggest that information be collected on sex, together with other variables such as age and nationality.

Some basic concepts for STP data and indicators

The following definitions may be useful for understanding some of the criteria for classifying STP. UNESCO has defined *education* as 'organized and sustained communication designed to bring about learning', while 'successfully completed education at a given level leads to a *formal qualification*'.

Occupation is defined in the most recent version (1988) of the ISCO (see below) in terms of *jobs*, or *posts*. A *job* is defined as 'a set of tasks and duties executed, or meant to be executed, by one person. A set of jobs whose main tasks and duties are characterized by a high degree of similarity constitutes an occupation. Persons are classified by occupation through their relationship to a past, present of future job'. Jobs require *skills* that are defined as 'the ability to carry out the tasks and duties of a given job'. Skills may be acquired through education or on-the-job (vocational) training.

Two dimensions of skills are defined in ISCO. The *skill level* is 'a function of the complexity and range of the tasks and duties involved'. *Skill specialization* is 'defined by the field of knowledge required, the tools and machinery used, the materials worked on or with, as well as the kinds of goods and services produced'. Four broad skills levels have been defined in ISCO-88 in terms of the educational categories and levels that appeared in ISCED-76 (now replaced by ISCED-97).[1] The first ISCO skill level was defined with reference to ISCED-76 Category 1, comprizing primary education, which generally begins at the age of 5, 6 or 7 and continues for about five years. The second skill level was defined with regard to ISCED-76 Categories 2 and 3, comprizing the first and second stages of secondary education, the first stage beginning at the age of 11 or 12 and continuing about three years; the second at the age of 14 or 15, for about three years. The third skill level was defined with reference to ISCED-76 Category 5, comprizing education beginning at the age of 17 or 18 and continuing about four years, leading to an award *not* equivalent to a first university degree. Finally, the fourth ISCO level was defined with reference to ISCED-76 Categories 6 and 7, comprizing education that also begins at the age of 17 or 18, continues for about three or more years, and leads to a university or postgraduate university degree or equivalent.

The ISCO skill levels 4 and 3 appear to be those of specific relevance to our analysis of stocks and flows of STP. However, as a result of the 1997 revision of ISCED, some problems of compatibility have occurred between the two classifications. A revision of ISCO is scheduled to be carried out within the next few years.

The International Standard Classification of Occupations (ISCO)

The *International Standard Classification of Occupations* is the principal standard for the collection and classification of general employment data. It is also used by the principal international agencies for measuring STP. The first version

1. See the ISCED-76 and ISCED-97 level categories in Figure 3.1.

was published in 1968; in 1988 it underwent a complete overhaul. The new ISCO guidelines are currently being implemented, but many of the statistics available in international and national databases are still based on the 1968 guidelines. The link or key between the 1988 and earlier version is, unfortunately, not satisfactory for a detailed long-term analysis of those occupations that are of specific interest to S&T because of the breaks in the series.

The conceptual structure of ISCO-88 consists of a pyramid with 10 major groups subdivided into 28 sub-groups, 118 minor groups and 390 unit groups. The ten major professional groups are reproduced in Figure 4.1. This figure also shows the relationship between the ten major groups and their skill levels, defined in terms of ISCED-76 (see above).

The Major groups 2 (Professionals) and 3 (Technicians and associate professionals) are of particular interest to the classification of STP (presented first). However, high-level STP (researchers and technicians) may also be found in the major groups 1 (legislators, senior officials and managers) and 0 (armed forces).

ISCO major group 2: Professionals

Major group 2, 'Professionals', includes occupations whose main tasks require a high level of professional knowledge and experience in the fields of physical and life sciences or social sciences and humanities. The main tasks consist in increasing the existing stock of knowledge, applying scientific and artistic concepts and theories to the solution of problems, and teaching those in group 2 in a systematic manner. Most occupations in this major group require skills at the fourth ISCO skill level.

It is also specified that tasks performed by professionals usually include: conducting analysis and research; developing concepts, theories and operational methods; advising on or applying existing knowledge related to physical sciences, including mathematics, engineering and technology, and to life sciences including the medical profession, as well as to social sciences and humanities; teaching the theory and practice of one or more disciplines at different educational levels; teaching and educating handicapped persons; providing various business, legal and social services; creating and performing works of

Figure 4.1: ISCO-88 major professional groups and related skill levels*

	Major groups of professions	ISCO skill level
1.	Legislators, senior officials and managers	–
2.	Professionals	4th
3.	Technicians and associate professionals	3rd
4.	Clerks	2nd
5.	Service workers and shop and market sales workers	2nd
6.	Skilled agricultural and fishery workers	2nd
7.	Craft and related trade workers	2nd
8.	Plant and machine operators and assemblers	2nd
9.	Elementary occupations	1st
0.	Armed forces	–

* Defined in terms of ISCED-76.

Figure 4.2: Major group 2: Professionals[2]

21 Physical, mathematical and engineering science professionals
- 211 Physicists, chemists and related professionals (4)
- 212 Mathematicians, statisticians and related professionals (2)
- 213 Computing professionals (3)
- 214 Architects, engineers and related professionals (9)

22 Life science and health professionals
- 221 Life science professionals (3)
- 222 Health professionals (except nursing) (5)
- 223 Nursing and midwifery professionals (1)

23 Teaching professionals
- 232 Secondary education teaching professionals (1)
- 233 Primary and pre-primary education teaching professionals (2)
- 231 College, university, higher education teaching professionals (1)
- 234 Special education teaching professionals (1)
- 235 Other teaching professionals (3)

24 Other professionals
- 241 Business professionals (3)
- 242 Legal professionals (3)
- 243 Archivists, librarians, related information professionals (2)
- 244 Social science and related professionals (6)
- 245 Writers and creative or performing artists (5)
- 246 Religious professionals (1)

art; providing spiritual guidance; and preparing scientific papers and reports.

This major group 'Professionals' is divided into four sub-major groups, which in turn are classified into minor groups and sub-unit groups (with number of subgroups inserted in brackets), listed in Figure 4.2.

ISCO major group 3: Technicians and associate professionals

This major group includes occupations whose main tasks require technical knowledge and experience in one or more fields of physical and life sciences or social sciences and humanities. The main tasks consist of carrying out technical work connected with the application of concepts and operational methods in the above-mentioned fields, and in teaching at certain educational levels. Most occupations in this major group require skills at the third ISCO level. Major group 3 'Technicians and associate professionals' is divided into the sub-major groups of occupations (number of sub-unit groups within brackets), listed in Figure 4.3.

Figure 4.3: Major group 3: Technicians and associate professionals[3]

31 Physical and engineering science associate professionals
- 311 Physical and engineering science technicians (9)
- 312 Computer associate professionals (3)
- 313 Optical and electronic equipment operators (4)
- 314 Ship and aircraft controllers and technicians (5)
- 315 Safety and quality inspectors (2)

32 Life science and health associate professionals
- 321 Life science technicians, related associate professionals (3)
- 322 Modern health associate professionals (exc. nursing) (9)
- 323 Nursing and midwifery associate professionals (2)
- 324 Traditional medicine practitioners and faith healers (2)

ISCO major group 1: Legislators, senior officials and managers

This major group is also relevant for measuring STP; however, S&T characteristics are rather difficult to identify within most of the professions classified in the group and, as a result, no reference has been made in ISCO to any corresponding skill levels. The problems are particularly pertinent for the sub-major group 131, 'General managers', for which no distinction is made; for instance, between managers of large multinational or domestic enterprises and managers of local fast-food shops.

The group includes occupations whose main tasks consist in determining and formulating government policies, as well as laws and public regulations, overseeing their implementation, representing governments and acting on behalf of, or planning, directing and coordinating the policies and

2 and 3. For more details about sub-groups, minor groups and unit groups, see *ISCO-88* or the *Canberra Manual* (Annex 4).

activities of enterprises and organizations, or departments. The principal sub-major groups are

- legislators and senior officials
- corporate managers, and
- general managers.

Persons involved in S&T are likely to be found within several of the sub-groups listed in Figure 4.4.

Among the above ISCO groups, that of 'Research and development department managers' (1237) is of specific interest to this toolkit. Their professional tasks are defined as 'the planning, direction and co-ordination of research and development activities of the enterprise or organization, under the broad guidance of the directors and chief executives, and in consultation with managers of other departments or sections'. This includes the development of new or improved technical processes and products, the control of financial resources, human resources management and related issues.

Figure 4.4: Major group 1: Legislators, senior officials and managers

122 Production and operations department managers
— in agriculture, hunting, forestry and fishing (1221)
— in manufacturing (1222)
— in construction (1223)
— in wholesale and retail trade (1224)
— in restaurants and hotels (1225)
— in transport, storage and communications (1226)
— in business services (1227)
— in personnel care, cleaning and related services (1228)
— not elsewhere classified (1229)
123 Other department managers
— Finance and administration department managers (1231)
— Personnel and industrial relations department managers (1232)
— Sales and marketing department managers (1233)
— Advertising and public relations department managers (1234)
— Supply and distribution department managers (1235)
— Computing services department managers (1236)
— Research and development department managers (1237) not elsewhere classified
131 General managers (the list of sub-classes of this group is identical with that of 122 above).

ISCO major group 0: The armed forces

The professions within this major group have traditionally been considered male domains, but in most countries the sector is expanding to include women. Scientific and technological qualifications and skills are increasingly emphasized, with the introduction of more and more sophisticated military equipment. Defence R&D still accounts for a major percentage of public R&D funding in many countries and employs large numbers of S&T staff. It is difficult to propose a breakdown of the different professions in this group, and, as in the case of major group 1, ISCO does not suggest any reference to skill levels in defining the scope of the 'armed forces'.

Note that the category of 'Researchers' (as discussed in the *Frascati Manual* below) is classified in the ISCO-88 major group 2 'Professionals' and in 'Research and development managers' (ISCO 1237). By convention, members of the 'armed forces' with similar skills who perform R&D should also be included in this category.

Breakdown of STP by occupation and education/formal qualification

The principal international classifications of STP and R&D personnel by occupation and/or education/formal qualification, and their more detailed breakdowns by relevant sub-categories will be discussed in this section.

The approach by occupation

The UNESCO *Recommendation* – STP

UNESCO recommends that data be collected for:

Scientists and engineers: 'persons who use or create scientific knowledge and engineering and technological principles, i.e. persons with scientific or technological training who are engaged in professional work on STA, high-level administrators and personnel who direct the execution of STA. In the case of R&D activities, scientists are synonymous with researchers and assistant researchers engaged both in the natural sciences and in social sciences and humanities'.

Technicians: 'persons engaged in that capacity in S&T who have received vocational or technical training in any branch of knowledge or technology'.

Auxiliary personnel: 'persons whose work is directly associated with the performance of STA, i.e. clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in the various trades, and all other supporting personnel'.

A few additional guidelines are supplied for the attribution of persons to the categories of 'scientists and engineers' or 'technicians':

Scientists and engineers are considered to have:

- completed higher education with an academic degree
- received third-level non-university education or training not leading to a similar academic degree but recognized as qualifying for a professional career
- received training or acquired professional experience recognized as being equivalent to one of the two preceding types of training, for example membership in a professional association or the holding of a professional certificate or licence.

Technicians are persons considered to have:

- completed the upper stage of secondary education, which in many cases is followed by one or two years of specialized technical courses
- received at least three years of vocational or technical education, whether or not leading to a diploma
- received on-the-job training or acquired professional experience that is nationally recognized as being equivalent to the former levels of education.

It should be noted that the above UNESCO definitions refer to the total stocks and flows of STP, which is a much wider concept than that of R&D personnel only. As far as R&D surveys are concerned, the OECD *Frascati* definitions have now been entirely adopted by UNESCO.

OECD *Frascati Manual* – R&D personnel

The *Frascati Manual* suggests the following categories:

Researchers: 'professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned' (OECD, 2002, p. 301). For this category OECD frequently uses the acronym RSE (Research Scientists and Engineers).

Technicians and equivalent staff: 'persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities' (p. 306).

The following tasks are performed by this category of personnel (p. 307):

- bibliographic searches and selection of relevant material from archives and libraries
- preparation of computer programmes
- carrying out of experiments, tests and analyses
- preparation of materials and equipment for experiments, tests and analyses
- recording of measurements, calculations and preparation of charts and graphs
- statistical surveys and interviews.

Other supporting staff: 'skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects (p. 309). 'All managers and administrators dealing mainly with financial and personnel matters and general administration, insofar as their activity is a direct service to R&D' (p. 311) should be included here.

The OECD/Eurostat *Canberra Manual* – HRST

The *Canberra Manual* provides a more logical and sophisticated approach to the breakdown of the global number of HRST. It is (still) strictly linked to ISCED-76 in terms of levels of education and to ISCO-88 in terms of major professional groups and related skill levels. It also frequently uses a cross-classification of the occupation/qualification criteria. Rather than distinguishing between occupations, the *Canberra Manual* proposes that HRST be split into two major categories: university-level HRST and technician-level HRST.

University-level HRST 'includes persons who fulfil one or other of the following conditions:

- successfully completed education at the third level of the type that leads to a first or postgraduate university degree or equivalent, in an S&T field of study; or

- not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required'.

Technician-level HRST 'includes persons who fulfil one or other of the following conditions:

- successfully completed education at the third level of the type that leads to an award not equivalent to a first or higher university degree, in an S&T field of study (other than those employed in occupations normally requiring a higher qualification); or
- not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required'.

Note that the *Canberra* concept of HRST neither includes the UNESCO STP category of 'Auxiliary personnel' nor the *Frascati* R&D personnel category of 'Other supporting staff'.

The approach by education/formal qualification

The UNESCO approach, based on ISCED-76, has already been presented in Chapter 3. The following breakdown of persons by formal qualification/education is proposed in the revised *Frascati Manual 2002*. The breakdown is defined exclusively by levels of education (according to ISCED-76) regardless of the discipline (field of science) in which the degree was obtained.

Holders of university degrees at PhD level: 'holders of doctorate degrees of university level or equivalent in all fields (ISCED Level 6). This category includes holders of degrees earned at universities proper and also at specialized institutes of university status' (OECD, 2002, p. 313).

Holders of basic university degrees below PhD level: 'holders of tertiary-level degrees below the PhD level in all fields (ISCED Level 5A). This category includes holders of degrees earned at universities proper and also at specialized institutes of university status' (p. 314).

Holders of other tertiary level diplomas: 'holders of other post-secondary tertiary (ISCED Level 5B) diplomas in all fields. Subject matter is typically specialized, presented at a level requiring the equivalent of full secondary level to master it. It provides a more practically oriented/occupation-specific education than programmes at ISCED Levels 5A and 6' (p. 315).

Holders of other post-secondary non-tertiary diplomas: 'holders of other post-secondary non-tertiary (ISCED Level 4) diplomas in all fields. This class includes holders of degrees preparing students for studies at Level 5, who although having completed ISCED Level 3, did not follow curriculum which would allow entry to Level 5, i.e. pre-degree foundation courses or short vocational programmes' (p. 316).

Holders of diplomas of secondary education: 'holders of diplomas at the secondary level, upper stage (ISCED Level 3). This class includes not only all ISCED Level 3 diplomas obtained in the secondary school system but also equivalent Level 3 vocational diplomas obtained from other types of educational establishments' (p. 317).

Other qualifications: 'all those with secondary diplomas at less than ISCED Level 3 or with incomplete secondary qualifications or education not falling under any of the other four classes' (p. 318).

In the *Canberra Manual*, university-level HRST is still defined as covering ISCED-76 Levels 6 and 7 and technician-level HRST as ISCED-76 Level 5 (see Chapter 3). The attributions should be made on the basis of the highest qualification held.

As mentioned above, the HRST concept has wide general coverage both in terms of ISCED levels and fields of study (NSE versus SSH). Depending on the specific interests of investigation, this coverage may have to be modulated in the data collection procedures. The *Canberra Manual*, therefore, has introduced the three concepts of *core coverage* (with those levels and fields which should always be included given their specific interest to S&T policy), *extended coverage* and *complete coverage*. The two latter concepts may be of slightly less general policy interest but must be taken into account at various levels of our S&T policy analysis (see Figure 4.5).

According to the *Canberra Manual*, university-level HRST is more important to STA and policies than technician-level HRST. It also states that international comparisons of data based on ISCED-76 Level 5 may be misleading because of differences in national education

Figure 4.5: Coverage for data collection, by field of study and level of education

Field of study	Level 6/7	Level 5
Natural sciences	core	extended
Engineering and technology	core	extended
Medical sciences	core	extended
Agricultural sciences	core	extended
Social sciences	core	extended
Humanities	extended	complete
Other fields	extended	complete

Source: *Canberra Manual*, based on ISCED-76.

systems. Third, lead times to train and develop university-level HRST are in general longer, and the costs involved higher, than for technician-level HRST. In terms of fields of study, some fields, like the natural sciences or engineering and technology, are often considered to be more directly relevant to STA than the social sciences, humanities or other fields. However, in the interest of collecting information on women's STA, these assertions may be less useful.

In this scheme, *core coverage* represents the areas of highest relevance to S&T policy (notably people with university-level degrees in the natural and social sciences). *Extended coverage* further includes both university-level degrees in the humanities and all technician-level degrees in the natural and social sciences, whereas *complete coverage* categories include every person qualified as HRST, regardless of level or field of study.

Eurostat has been the principal user of the *Canberra Manual* both for data collection and analysis and further methodological developments. The original HRST definitions have been completed with some additional refinements based on the 1997 revision of ISCED of interest to policy analysis, such as coining new terminology for categories of persons fulfilling at least one of the HRST conditions:

HRSTE – successfully completed education at the third level in a S&T field of study

HRSTO – not formally qualified but employed in a S&T occupation normally requiring such qualifications

HRSTC – human resources in S&T – core

HRSTU – human resources in S&T – unemployed

NHRSTU – no education at the third level in an S&T field of study but unemployed.

Measuring the activities of STP

Full-Time Equivalence (FTE) and Head Counts (HC)

The discussion of human resources devoted to STA (including R&D) has so far focused on data series where the individual is the statistical unit. This, of course, is a logical approach for gendered analysis as well as for analysing other variables of the labour force, such as age and national origin. In this section the head-count (HC) approach will be presented, along with methods of measuring S&T/R&D personnel in terms of full-time equivalence (FTE).

The FTE approach was for many years preferred by the OECD and UNESCO in their R&D surveys. However, R&D is not the primary function of all those involved. In many cases, R&D is a secondary function or a part-time activity, that is for university teachers and post-graduate students. Using only HCs as a measure of R&D personnel would at times seriously overestimate the 'real' (global) R&D effort. For example, university faculty are usually engaged in a number of S&T-related activities other than R&D, such as teaching, administration, library work, and medical healthcare. HC data allow comparisons with other series, such as demographic, education and employment statistics, and, further, are often a prerequisite for the calculation of FTE data. Currently, interest is turning to

the HC approach for calculation of R&D/STP in a wider S&T perspective. Both FTE and HC approaches are now standard in the principal international R&D surveys.

HC data principally refer to a given date of observation, whereas FTE series relate to a given time period. As a rule this is the calendar year, but FTE series may also pertain, for instance, to the academic or fiscal years.

The calculation of FTE may be subjective and depends on the survey or estimation method used. This is particularly true concerning S&T/R&D data for the university sector. To date, there are neither identical national systems of higher education nor identical methods of surveying the S&T/R&D resources (personnel and expenditures) in the sector. Some countries have developed sophisticated methods – time-budget surveys, for instance – of calculating R&D shares (and, of course, also time shares of their other activities) of total working time. Such actions may provide S&T/R&D coefficients that are then used to calculate disaggregated series of principal statistical variables, such as fields of study, types of costs, or sources of funds. Elsewhere, data are obtained through simple desk work where some kind of rough rule-of-thumb ratio (50–50 or 70–30 per cent for instance) is applied at aggregated levels of central administrative and financial data series.[4]

HC data are normally easier to collect than FTE because they refer to a specific unit, as a rule of employment.

HC data: Drawing on the *Frascati* guidelines, the *Canberra Manual* stresses the utility of HCs for the measurement of stocks and flows of STP, notably for comparisons over time. HC data allow the calculation of net changes in total STP, including disaggregation of sex, as well as, for instance, growth rates.

The *Frascati Manual* suggests three approaches for measuring HCs (OECD, 2002, p. 329). They include:

- the number of persons engaged in R&D on a given date (e.g. end of period)
- the average number of persons engaged in R&D during the (calendar) year; or
- the total number of persons engaged in R&D during the (calendar) year.

The first two options are preferable for the measurement of total stocks of STP. The third option may be of interest in S&T fields or institutions with high mobility of personnel during the year. The UNESCO *Recommendation* discusses a breakdown between full- and part-time STP. These concepts were further developed in the *Frascati Manual*, which defined *full-time* as persons working at least 90 per cent (on R&D), *mainly* (50–90 per cent) and *part-time* (less than 50 per cent), and suggested that those spending less than 10 per cent of their working time on R&D be excluded. This approach is no longer recommended in the 2002 revision of the *Frascati Manual*.

FTE data: As discussed in the *Frascati* and *Canberra* manuals,

> one FTE may be thought of as one person-year. Thus, a person who normally spends 30 per cent of his/her time on R&D and the rest on other activities (such as teaching, university administration and student counselling) should be considered as 0.3 FTE. Similarly, if a full-time R&D worker is employed at an R&D unit for only six months, this results in an FTE of 0.5. Since the normal working day (period) may differ from sector to sector and even from institution to institution, it is not meaningful to express FTE in person-hours (OECD, 2002, p. 333).

For historical reasons, the *Frascati Manual* appears to give priority to the collection of FTE data, whereas the *Canberra Manual* prefers the HC approach. As mentioned above, the two approaches now receive equal attention in international data collection. The final choice between HC and FTE will, therefore, depend on the outcome to be investigated.

Stocks and flows of STP

Stocks of STP may be seen as a snapshot of a situation at a given point in time, while flows (inflows or outflows) relate to movements in or out of a stock during a particular period of time.

These concepts have been defined in more detail pertaining to the HRST in the *Canberra Manual* drawing on, among other sources, the guidelines of the *System of National Accounts* (ISWGNA, 1994). An HRST 'stock' can be defined as the number of people who, at a particular point in time, fulfil the conditions of the definition of HRST. 'Flows' of HRST can be defined as the number of

4. For more detailed information on various methods of measuring/estimating the FTE in the higher education sector, see Annex 2 of the *Frascati Manual 2002*.

people who do not fulfil any of the conditions for inclusion in the HRST at the beginning of a time period, but gain at least one or other of them during that period (inflow), and the number of people who fulfil one or other of the conditions of the definition of HRST at the beginning of the time period and cease to fulfil them during that period (outflow).

The *Canberra Manual* gives the following examples. A stock figure is, for instance, the number of PhDs in physics in a given country and sector on a given date. An example of inflow is the number of electronics engineers graduating from a country's universities in a given year. Inflows to stocks may also consist of, for instance, qualified immigrants. Outflows consist of qualified emigrants, deaths, and so on.

Internal flows of HRST refer to persons who, being part of and remaining in the HRST stock, change their sector of employment or field of STA, or achieve a qualification at a higher ISCED level during the period concerned.

Stocks and flow of STP may be subdivided into a number of subsets based on various criteria, either personal or geographical, such as sectors of activity, occupation, or status of employment. Breakdowns by sex of stock and flow data may provide useful and pertinent information to policy-makers.

With respect to the aggregated stocks of STP, UNESCO suggested a breakdown of S&T potential by (i) the total stock of qualified manpower and (ii) the number of economically active qualified manpower (see the *Recommendation*). The 'total stock of qualified manpower' comprizes the total number of persons with the necessary qualifications for personnel in categories 'scientists and engineers' and 'technicians', regardless of economic activity (such as production, STA, the professions, no gainful employment), age, sex, nationality or other characteristics, who are present in the domestic territory of a country at a given reference date.

The 'number of economically active qualified manpower' comprizes the total number of persons with the necessary qualifications for the categories 'scientists and engineers' and 'technicians' who are engaged in, or actively seeking work in, some branch of the economy at a given reference date.

The first (total stock) approach is probably of greatest policy interest. It should allow the identification of underutilized or hidden human resources for S&T. Importantly, provided the data is disaggregated by sex, this is also where the potential contributions of women to S&T may be estimated. On the other hand, the second (economically active) approach may inform us about the current involvement of women in the national economy, and provide information on numbers of unemployed women actively seeking employment.

These guidelines have not led to any substantial data collection or diffusion. Until 1995, information on stocks was published in the UNESCO *Statistical Yearbook*. In the 1995 edition, STP stock data was presented for some eighty countries (less than half of the UNESCO Member Countries) for the first time. Data referred either to total stocks or stocks of potential scientists, engineers and technicians. Some three-quarters of those countries for which data was presented had chosen the economically active approach, while less than one-quarter used the total stock approach.

Where are STP located in the economy? Sectors of employment and performance

Information on where STP are working across the economy is of great policy interest. We know, for instance, that women are increasingly represented in university education, but it is also important to know where they go for their first job and if their career prospects differ in various disciplines or sectors of the economy.

To measure economic and human R&D resources – which besides education is the best-developed branch of S&T statistics – both UNESCO and the OECD from the very beginning proposed breakdowns by sectors of R&D performance and employment of the R&D personnel. Although based to varying extents on the *System of National Accounts* (ISWGNA 1994), the categories originally developed by each institution differed according to the economic systems of their member states. The economies of OECD members were structured in similar ways, so that one common sectoring approach was applicable. UNESCO in contrast was required to develop a system of sectors that would apply to the Western countries (most already members of the OECD), the former socialist countries and to the industrializing world. Only the higher education sector (see below) was the same in the two systems.

Since the late 1990s the OECD *Frascati* approach to sectoring has been fully adopted by UNESCO for the international R&D surveys of the UIS but also, at the national level, by an increasing number of countries and economies.

The *Frascati Manual* – Sectors of performance/employment

The following four sectors of R&D performance and employment are suggested in the *Frascati Manual*. This sectoring approach is also used for sources of R&D finance (together with a fifth sector, 'from abroad').

1. the Business Enterprise (BE) sector
2. the Government sector
3. the Private Non-Profit (PNP) sector
4. the Higher Education (HE) sector.

The BE sector includes 'all firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price (and) private non-profit institutions mainly serving them' (OECD, 2002, p. 163). In brief, this sector covers private and public enterprises, notably in manufacturing and services, as well as institutes serving other units of the sector.

The Government sector consists of 'all departments, offices and other bodies that furnish, but normally do not sell to the community; those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community (public enterprises are included in the business enterprise sector)'. Also included in this sector are non-profit institutions controlled and mainly financed by government (excluding the HE sector), (p. 184).

The HE sector is composed of 'all universities, colleges of technology, and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions' (p. 206).

The PNP sector covers 'non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households' (p. 194). For the latter, the new acronym NPI has recently been introduced. The PNP sector, for instance, includes professional or philanthropic learned societies, charities, relief or aid agencies, trade unions and consumer associations, and others. It is usually not a very active performer of R&D or employer of R&D personnel itself, but it sometimes plays an important role as a source of finance in national R&D efforts, notably for R&D performed in universities and other institutions of higher education.

Disaggregating sector approaches – Sector classifications

Some of the detailed institutional breakdowns recommended for international comparisons as discussed in the *Frascati* and *Canberra* manuals will be presented below.

The *International Standard Industrial Classification of All Economic Activities* (ISIC) is primarily used for surveys of expenditures and employment in the BE sector, especially for manufacturing industries, institutes serving them and services. Its application, however, is wider, and with relevant disaggregations its broad groups may be applied to other sectors of the economy as well. ISIC (3rd revision 1990, mini-revision 2002) is harmonized with the *General Nomenclature of Economic Activities* (NACE) of the European Union.

The *Canberra Manual* recommends the minimum list of ISIC classes for the measurement of HRST presented in Figure 4.6.

For more details on proposed disaggregations of ISIC classes of the BE sector, see the options presented in the *Frascati* (specifically rearranged for the purposes of R&D statistics) and the *Canberra* manuals. They suggest that sixty to eighty different industry groups and sub-groups could be distinguished (OECD, 2002, Table 3.1).

For the HE and PNP sectors, the principal institutional classification used is that of ISCED, applied as the following six major fields of science (see the discussions of ISCED-76 in Chapter 3), that is the natural sciences, engineering and technology, medical sciences, agricultural sciences, social sciences and the humanities.

For the Government sector, the United Nations' *Classification of the Functions of Government* (COFOG) is primarily used for the measurement of a certain number of variables. It has, however, not been considered appropriate for the classification of public R&D activities and, in the absence of appropriate compromises, no specific sub-classification is proposed in the *Frascati Manual*. Yet COFOG could possibly serve for the measurement of HRST, including gender trends, in this sector.

The functional/institutional contents (ten principal classes) of the *Classification of the Functions of Government* (COFOG) are listed as follows:

01 General public services
02 Defence
03 Public order and safety
04 Economic affairs
05 Environmental protection
06 Housing and community amenities
07 Health
08 Recreation, culture and religion
09 Education
10 Social protection.

Other variables for the collection of S&T data

The status of the S&T labour force:

We have discussed technical matters of calculating the FTE of STP working full-time, working mainly, or working part-time on R&D. From the policy perspective, these issues should also be examined with regard to the employment status of the S&T labour force. Employment conditions are becoming unstable and increasingly based on short-term, fixed-duration or open-ended contracts. They also vary considerably between sectors and categories of STP. In a number of countries, fixed duration contracts are quite common for young scientists in their early academic careers, and research is often coupled with teaching duties.

Figure 4.6: Possible use of ISIC for the classification of HRST

Economic activity	ISIC division
Agriculture	01, 02, 05
Mining	10, 11, 12, 13, 14
Manufacturing (could be further disaggregated)	15 through 37
Utilities	40
Construction	45
Transport, storage, communications	60, 61, 62, 63, 64
Computing and related activities	72
R&D	73
Other business activities	74
Public administration and defence	75
Education	80
Health	85
Other	50, 51, 52, 55, 65, 67, 70, 71, 90, 92, 93, 95, 99

Recent studies around the world seem to indicate that, with similar qualifications, men are more likely than women to occupy permanent positions, and women are more likely than men to work on a part-time basis. More information is needed on the employment status of STP in general and on related gender issues in particular. The *Canberra Manual* recommends that information be collected on permanent full-time staff, permanent part-time staff (normally defined as under twenty hours per week), and short-term contract staff (defined as people with contracts having a duration of less than three years).

Age

The *Canberra Manual* refers to the value of collecting more information on the age profile of the S&T labour force, both for stocks and flows. In terms of stocks, it is important to know the composition of different age categories in order to plan for the replacement of those approaching retirement. In terms of flows – especially concerning numbers of students still in the education pipeline – it is useful to have information on future supplies of highly qualified personnel. This information should be broken down by fields of study (in general) and, as discussed in earlier chapters, by sex.

For general education statistics (flows), the age breakdown currently used in the common questionnaires of OECD/UNESCO/Eurostat is as follows (these education statistics also, as a rule, propose a breakdown by sex):

- under 16 years of age
- 16–29
- 30–34
- 35–39
- 40 and over (together with a class [age unknown]).

The *Frascati Manual* (on R&D personnel) recommends the following six age categories:

- under 25 years of age
- 25–34
- 35–44
- 45–54
- 55–64
- 65 and more.

For stocks of HRST, the *Canberra Manual* recommends the following six age categories:

- less than 30 years
- 30–39 years of age
- 40–49
- 50–59
- 60–69
- 70 and over.

These categories are based on and compatible with the recommendations of the UN *Provisional Guidelines on Standard International Age Classification* (1982) and the ILO's *Sources and Methods* volumes for censuses and household surveys.

National origin

The dependency on scientists and engineers as well as other qualified personnel from abroad is becoming a specific concern in many countries in both the North and the South. Here, gender issues are perhaps of less importance than other STP indicators,[5] but information by gender is of clear policy interest in that it may reflect policies on HRST in the countries of reception and origin. The *Canberra Manual* discusses a number of possible criteria for classification by origin, including country of birth, country of previous residence, country of study at the highest level and citizenship. As for students, UNESCO defines a foreign student in its surveys on statistics of education at the tertiary level (higher education) as a person 'enrolled at an institution of higher education in a country of which he is not a permanent resident. Accordingly country of origin is the country in which the student is permanently resident (home country)'.

Ethnicity

Data on ethnicity are commonly used in some countries for monitoring equal opportunity policies and assessing pools of under-utilized skills (see, for instance, the NSF's publication *Women, Minorities and Persons with Disabilities in Science and Engineering*). Elsewhere such information is less available. More detailed cross-classifications of series by ethnicity and sex would in some cases be of significant policy importance.

5. However, it might be useful to have sex-disaggregated data on the brain drain to assess whether gender plays a role in decisions to work abroad.

Chapter 5

Collecting gender-disaggregated data: Case studies and models

Introduction

The previous two chapters outlined the theoretical and methodological approaches of the main international guidelines for the collection of data on STA and STP. This chapter presents resources and guidelines for collecting sex-disaggregated data. It begins by presenting the principal S&T data series and sources available at international and national levels, with some preference given to education statistics and indicators. Education (at all levels) is still the area for which the most complete and possibly the most internationally comparable series of statistics and indicators can be found. The chapter will also include new approaches for collecting sex-disaggregated data in other areas where women engage in STA, including related professions and the practice of non-formal S&T (namely, in the informal sector).

This chapter summarizes and presents examples of current and recent initiatives to collect data on women's participation in various S&T sectors. It looks broadly at collecting data in three main areas of women's STA:

- formal S&T education and careers
- women's participation in agricultural production
- women's informal-sector activities and enterprises.

The examples and case studies address three main issues in collecting sex-disaggregated data:

- the make-up and collection of gender indicators
- potential indicators in the three areas
- data collection methods.

Gender indicators

To begin, it will be useful to revisit the idea of a gender indicator, and the quantitative and qualitative aspects of sex-disaggregated data. As described by the Canadian International development Agency's *Guide to Gender-Sensitive Indicators* (CIDA, 1997, 3.11):

> An indicator is a pointer. It can be a measurement, a number, a fact, an opinion or a perception that points at a specific condition or situation, and measures changes in that condition or situation over time. In other words, indicators provide a close look at the results of initiative and actions. For this reason, they are front-line instruments in monitoring and evaluating development work.
>
> [...]
>
> Gender-sensitive indicators have the special function of pointing out gender-related changes in society over time. Their usefulness lies in their ability to point to changes in the status and roles of women and men over time, and therefore to measure whether gender equity is being achieved. Because use of indicators and other relevant evaluation techniques will lead to a better understanding of how results can be achieved, using gender-sensitive indicators will also feed into more effective future planning and program delivery.

An indicator can also be described as a set of statistics arranged to answer a specific question (to 'ring a bell' or provide early warning). Indicators are usually obtained by comparing original raw data with some other internal or external variables. They take the form, for example, of ratios, percentages and growth rates, or are seen in relation to the population, to the GDP or to other economic variables.

There are three main criteria for choosing useful S&T indicators:

1. **Policy relevance and utility**. The ideal indicator should:

- be simple, easy to interpret and capable of showing trends over time
- be responsive to changes in the S&T environment and related human activities
- provide a basis for international comparisons
- be either national in scope or applicable to regional S&T issues of national significance
- have a threshold of reference value against which to compare it, so that users can assess the significance of the value associated with it.

2. **Analytical soundness**. An ideal indicator should:

- be theoretically well founded in technical and scientific terms
- be based on international standards and international consensus about its validity
- lend itself to being linked to economic models, forecasting and information systems.

3. **Measurability**. The data required to support the indicator should be:

- readily available, or made available at a reasonable cost/benefit ratio
- adequately documented and of known quality
- updated at regular intervals in accordance with reliable procedures.

Indicators should also be: user friendly, comprehensible, timely and few in number, as well as disaggregated by sex, age and other factors wherever feasible. The ultimate goal is to produce a small number of indicators that satisfactorily explain a maximum of phenomena to a broad array of users.

In developing gender-sensitive indicators, it has been pointed out that the use solely of quantitative indicators gives an incomplete picture of the situation of women, and that a combination of quantitative and qualitative indicators will best indicate gender-related changes in society over time. Here quantitative indicators would be defined as *measures of quantity*, while qualitative indicators would be defined as people's *judgments and perceptions about a subject* (for example, the confidence people have in sewing machines as instruments of financial independence). They are particularly useful in understanding local people's views and priorities related to development and development projects. Therefore, quantitative indicators are extracted from more formal surveys, while qualitative indicators are extracted from less formal surveys, such as public hearings, interviews participatory rural appraisal, participant observation and attitude surveys.

The two types of indicators are complementary, and both are important for effective monitoring and evaluation of the effects on women of national and project-level activities. This is because they can cross-validate and identify problems of each.

BOX 5.1: INDICATORS OF CHANGE IN RURAL INDIA

An innovative study on the incidence of poverty in two Indian villages was carried out over twenty years by Jodha (1989) between 1964 and 1984. Jodha gathered quantitative indicators on household income and used these indicators to chart the fortunes of the different households; the findings from these quantitative indicators were that 38 per cent of sample households had become poorer during this twenty-year period.

Unusually, Jodha also collected qualitative indicators from farmers who were deemed to have become poorer. Poor farmers' qualitative indicators or perceptions of change over the twenty-year period were phrased not in terms of declining income but rather in terms of: reduced reliance on patrons, reduced dependence on low-paid jobs, improved mobility and improved assets. Even though these farmers had become poorer in monetary terms, they considered that their quality of life had improved.

Jodha then uses qualitative analysis to examine why, because of social changes in their villages, poor people felt that they were better off, the main reasons being because they had greater independence, more mobility and were no longer at the mercy of the village elite. Jodha's is one of the best studies to show how quantitative and qualitative indicators can cross-validate each other and why there might be differences between the two kinds of indicators.

Source: CIDA, 1997.

Qualitative analysis, while not specifically addressed in this toolkit, is a useful way of determining why a certain situation exists. It is used to understand social processes, why and how a particular situation measured by indicators came into being, and how this situation can be changed in the future. An example of qualitative analysis is the examination of gender roles, that is, the different roles that women and men have in society, how these came into place and how they can be changed.[1]

Indicators of participation

A series of quantitative and qualitative indicators can be used to indicate the degree of participation in development projects including:

- involvement in an externally formulated project, usually providing some form of labour (for example, to a cash-for-work or income-generating scheme)
- involvement in decision-making and control over the project through the project cycle, probably also involving the provision of labour.

Selecting indicators

There is obviously no such thing as a set of universal indicators. Users must design and adapt indicators for their own purposes. The most important criteria to bear in mind are outlined below.

Developing gender-disaggregated indicators in S&T

Recently new work in collecting sex-disaggregated data in many areas has emerged. This is partly in response to recent UN statements on the importance of valuing women's unpaid work and of better understanding women's contributions to national economies and knowledge generation.[2] By far the most work has been done in the area of female education from primary to post-graduate levels, and in women's subsequent participation in S&T professions.

In each of the areas addressed below, gender indicators are generated from manipulation of existing or standard statistics and indicators. In some cases, they may be derived from the use of new data collection methods incorporating existing and new quantitative data complemented by qualitative data.

It should be noted that while the indicators suggested or discussed may need further testing and refinement, they are presented here as a basis on which to build or to inform further work.

Education and S&T statistics and indicators[3]

Contextual data at the principal international agencies

For the analysis of past, current and future trends, the following information (statistics, indicators and/or sources of data) is suggested by the principal agencies engaged in data collection of STP and STA (not all with breakdowns by gender).

General

Since the late 1990s, considerable interest has been expressed in women's engagement in STA, and this concern is reflected in the increasing generation of new sex-disaggregated data by international agencies and countries. It is, in general, a matter of extending already existing standardized data series of human resources – education and R&D statistics, in particular – to which the additional criterion 'female' has been added. This is plainly illustrated in the inventories of UNESCO and OECD data presented below, as well as gender-related analytical work. The principal step forward in the area of gender indicators is the work of the Women and Science Group (WSG) of the EC's Directorate-General for Research in Brussels, in close cooperation with Eurostat, the EC's Statistical Office in Luxembourg. In addition to the 'traditional' information on women's studies by fields of science at various ISCED levels, solid statistical information is now available which supports other findings of inequity in men's and women's professional career paths in universities, academia and R&D, as well as in women's participation at the highest levels of decision-making and planning processes.

1. See Huyer et al., 2005, for qualitative analysis of women's participation in the information society.
2. See ECOSOC, 1996
3. This section is drawn from UNESCO, 1997; Gilbert and Pomfret, 1995; Kochen et al., 1998; Inch et al., 1993; Bond, 1997.

While the gender dimension is essentially a complementary activity to other work at UNESCO and the OECD, the EU's Women and Science group is exclusively engaged in monitoring progress towards gender equity in S&T, through substantial statistical and analytical activities. The publication *She Figures 2003* will be presented below, after presenting the UNESCO and OECD education and S&T statistics, which until now, have constituted the primary sources of internationally comparable gender-disaggregated data (see Figure 5.1).

The basic UNESCO education and R&D statistics

In its guide to *Gender-Sensitive Education Statistics and Indicators,* UNESCO has outlined methods of 'engendering' some of the most commonly available education statistics and indicators, or using them to analyse and understand gender trends. It discusses the feasibility of producing data aimed at monitoring gender disparities in education. It presents concepts, methods and techniques for the systematic collection, analysis, presentation (including the use of graphic presentations) and dissemination of gender-sensitive information, and provides guidance to education policy-makers and managers. Furthermore, it suggests a small number of education-oriented indicators and indices (see below).

Data required for measuring sex ratios in education can be collected from different sources in various ways. Essentially, the data sources are categorized in two ways: as individual persons, such as students, teaching staff, parents, other members of the family, community leaders and employers; and as educational institutions, including

Figure 5.1: Data on education and literacy

Methods of collection	Variables collected
Population censuses	• Illiteracy • Educational attainment • School attendance • Fields of study
Household (or other) sample surveys	• Additional data on illiteracy and educational attainment • Household educational expenditures • Qualitative data
Periodic school surveys	• Other specific subjects (reasons for drop-out, parents', teachers', communities' expectations or opinions) • Pupils/students by sex, age, grade, field of study; • Repeaters, graduates
Administrative files	• Educational expenditures • Teachers' salaries • Teaching and other staff by age, qualification, status, etc. • Examination results

Source: UNESCO, 1997.

schools and universities, adult education centres, and other places of learning and training. Methods of collection may also include regular school surveys and administration reporting, population censuses and household surveys.

Current data gathered from regular school surveys and population censuses are essential for obtaining a general outlook on sex differences in illiteracy and education, access to school, participation and others. Specific additional data are necessary if one wants to study more in depth the reasons for inequalities in order to identify appropriate measures to reduce disparities. It may be interesting to identify reasons for drop-out, low or no school attendance of girls, and low female participation in S&T fields; and to analyse other elements such as children and community's needs, parents' perceptions and expectations, and others. Similarly, information is needed about aspects of the supply of education, for example public policies, resources allocation and school infrastructure. For this kind of information, ad hoc (sample) surveys are best suited, though cost considerations limit their use.

Factors affecting gender equality in education

The various factors affecting gender equality in education can be grouped into four main categories. On the demand side, socio-economic and cultural factors will affect the behaviour and the choices of parents and students. On the supply side, political and institutional factors and factors linked to the school will affect gender equality.

Engendering data and indicators on literacy and education: Gender-sensitive education statistics and indicators

According to UNESCO's guide, *Gender-Sensitive Education Statistics and Indicators*, gender issues can be considered with reference to different types of data sets. At the simplest level, one can consider the absolute figures and the absolute difference between the numbers of male and female illiteracy rates, pupils, students and teachers. Similar considerations can be applied to derived statistics in the form of indicators, such as literacy rates, admission rates, enrolment ratios and school survival. At a more sophisticated level, one can use specific gender-disparity indicators, as well as multivariate statistical methods, for the purposes of a more in-depth analysis.

The principal examples in the guide draw on statistics from various UNESCO databases for the main regions of the world (developing countries: sub-Saharan Africa, Arab States, Latin America/Caribbean, Eastern Asia/Oceania, Southern Asia, and developed countries), at the macro-economic level. They deal with regional or national totals of global variables (numbers of illiterate persons, enrolments, etc.). Pending the availability of sufficiently detailed data, the same kind of indicators could, however, be tested at disaggregated levels, for instance for individual countries and fields of study.

Illiteracy

The examples presented below are extracted from the guide. Even if the statistics used are no longer up-to-date, they nevertheless enable a better understanding of the indicators concerned.

Illiteracy data

- The percentage of female illiterates in the total number of illiterates is one of the simplest and most commonly used indicators of gender disparity.
- The sex ratio, similar to the sex ratio used in demography, represents the ratio between the number of male and female illiterates. In the case of perfect equity, the ratio equals 1. It can also be expressed as a percentage, giving the number of illiterate men per 100 illiterate women or vice versa.
- Other possibilities of measuring disparities can be envisaged, such as the relative gap given by the formula (F-M)/F x 100, which indicates the *proportion* of illiterate women that must be made literate to achieve parity with men.

Example 1. Estimated adult illiterate population aged 15 and over, by sex and by region, 1995

The following information is presented in this table:

- estimated number of adult illiterates in millions (both sexes, male (M) and female (F))
- absolute gap in millions = (F-M)
- the percentage of female illiterates in the total number of illiterates
- the sex ratio (the ratio between the number of male and female illiterates = M/F)

Figure 5.2: Factors affecting gender equality in education

Demand	Supply
Socio-economic factors • Poverty • Direct costs (feeds, uniform, transportation) • High opportunity costs/lower rate of return • Girls needed for household/agricultural tasks • Residence in remote, low population areas • Limited employment opportunities for graduates • Lower remuneration for women	**Political/institutional factors** • Budget constrains • Structural adjustment programmes • Insufficient public support for the poor • Political instability • Inconsistent educational policies • Poor quality of education programmes • Ill-adaptation of education systems to local learning needs • Lack of clear strategy for women and girls' education • Lack of public support for women in scientific activities • Limited employment prospects • Poor data collection mechanisms • Inadequate elements for progress assessment and policy formulation
Cultural factors • Parents' low level of education • Lower priority for girls' education • Girls' education perceived as incompatible with traditional beliefs and/or religious principles • Early marriages and pregnancies • Role of the girl/woman as a wife and mother • Sceptical attitudes towards the benefits and outcomes from educating girls	**Factors linked to the school** • Limited school/classroom space • High school fees • Low proportion of female teachers • Teachers untrained/not sensitised to gender issues • Stereotypes at school (curricula, textbooks) • School curricula in conflict with traditional culture • Orientation of girls/women to non-scientific fields • Lack of accommodation for or exclusion of pregnant adolescents and young mothers • Sexual harassment; insecurity • Distance from school • Lack of school canteens • Poor quality of hygienic facilities • School calendar incompatible with farming cycles

Source: UNESCO, 1997.

- the proportion of illiterate women to be made literate to achieve parity with men
- percentage of illiterate women among women = (F-M/Fx100).

Illiteracy rates

It is always necessary, when analysing education and literacy, to use relative values (such as the rates and ratios calculated in relation to the corresponding population), as well as absolute figures. To facilitate the analysis of both the overall illiteracy rates and the disparities, the absolute gender gap is given by the difference between female and male illiteracy rates (F-M), and is expressed in percentage points.

Example 2. Estimated adult illiteracy rates and gender gap, by sex and by region, 1995

The following information is supplied in this table:

- Illiteracy rates (per cent) for both sexes – male and female
- Absolute gap (F-M, in percentage points).

For more details on regional disparities, see UIS, 1997.

School participation

Gross enrolment ratios (GER)

Through the GER we can study:

- the current female enrolment ratio as compared with the male enrolment ratio
- the implied, absolute, gender gap (see above)
- the sex ratio, here defined as the ratio between the female and male enrolment ratios, and designated as the Gender Parity Index (GPI).

Absolute gender gaps versus relative gender disparities

The absolute gender gap (M-F) and the GPI (F/M) depict disparities in different methods of analysis and will be interesting depending on the context.

Example 3. Male and female GER and gender disparities, by region, 1992

The following information is supplied:

- GER in 1) primary education and 2) in secondary education
- For both 1) and 2): male (per cent), female (per cent), absolute gap (M-F, in percentage points), and gender parity index (GPI = the female to the male enrolment ratio F/M).

Changes over time in GER and gender disparities

Having assessed gender disparities at a given moment, one can proceed to an analysis of changes over time. From this can be calculated the variations in the female enrolment ratios and gender gaps over a period of time. A similar analysis can be made based on the gender parity index (GPI).

Example 4. Arab States: Male and female GER, gender gaps and GPI for primary and secondary education combined, 1994.

The following information is presented:

- Enrolment ratios (per cent) – male and female
- Absolute gaps (M-F, in percentage points)
- GPI (F/M).

Example 5. Arab States: Cross-country dispersion in male and female GER, gender gap and GPI, in primary and secondary education combined, 1994.

The same information as in Example 4 is supplied here, expressed in statistical terms of the mean value; the highest and lowest values, the range, the standard deviation and the coefficient of variation.

Example 6. Male and female GER in primary and secondary education, and gender gaps by region, 1985 and 1992.

Compared to previous tables, describing gender disparities in terms of GER and gaps at a given moment in time, this table provides a description of the same disparities over a given time period.

Example 7. Male and female GER in primary and secondary education, and gender gaps by region, changes between 1985 and 1992 (in percentage points).

This table describes the variations and gaps of Example 6 as percentages.

School participation and school survival

- In most developing countries, girls and women have less access to and participation in schooling than boys and men, as shown by an analysis of gender disparities in intake (entrance) rates into primary education and enrolment ratios.
- It is of interest also to examine the behaviour of girls as compared to boys once they are in school, that is, whether they tend to remain in school more or less than boys, and indeed whether they perform better or worse than boys.
- As a first step one may compare gender disparities as regards access to schooling with disparities as regards school survival. Access to schooling is measured by the apparent intake (entrance) rate while school survival can be given by the estimated percentage, for example, of a cohort of pupils who have entered Grade 1 in a given year and eventually reach Grade 5.
- It should be mentioned that the two types of measures are not strictly comparable, since, while the apparent intake rate can exceed 100 per cent due to early and late entrants into school, the survival rates to Grade 5 cannot exceed 100 per cent.[4] Thus no country-to-country comparisons between the absolute gaps can be made. It is legitimate, however, to make country-to-country comparisons according to the GPI.
- Another way of analysing differences in the school life of boys and girls is to compare male and female school life expectancy (SLE) and school survival expectancy (SSE). The SLE is the total number of years of schooling which a child of a certain age can expect to receive in the future. The SSE is the number of years of schooling which a child of a certain age *who is already at school* can expect to receive in the future.[5]

Example 8. Sub-Saharan Africa: School access and survival to Grade 5, 1992.

This table describes gender differences as regards access to (apparent intake rate in 1992) and participation in schooling (percentage of 1991 cohort reaching Grade 5), with – for both variables – the male percentage, the female percentage, the absolute gaps in percentage points, and the GPI.

Example 9. Male and female SLE and SSE and gender gaps, 1992.

The SLE and the SSE are expressed in years of schooling, for males and females, with an indicator of the 'absolute gap' between the sexes.

Index of sex segregation by fields of study

It may be useful, when studying female participation in the different fields of study in vocational, technical or higher education, to possess a tool to measure how men and women tend to concentrate in specifically 'masculine' or 'feminine' fields, respectively. The sex segregation index (SSI) by fields of study can constitute such a tool. It is defined as the percentage of all persons enrolled at a given level of education who would need to change their field of study if the ratio of females to males were to be the same in all fields (assuming that there were no change in the total enrolment).

In effect, the index equalizes the composition by sex of enrolments in all fields of study on the basis of the composition by sex of the total enrolment in all fields of study taken together. For example:

4. The *apparent intake rate* (entrance rate) is the number of new entrants into Grade 1, first level, regardless of age, expressed as a percentage of the population of official admission age to the first level of education. The *percentage of a cohort reaching Grade 5* (survival to Grade 5) is the percentage of children starting primary school, who eventually attain Grade 5. The estimate is based on the reconstructed cohort method, which uses data on enrolment and repeaters for two consecutive years.
5. The definitions of the two indicators given in the *World Education Report 1995* (UNESCO, 1995) are as follows:

School life expectancy (SLE): For a child of a certain age, the SLE is defined as the total number of years of schooling which the child can expect to receive in the future, assuming that the probabilities of his or her being enrolled at school at any particular future age is equal to the current enrolment ratio for that age. It is the sum of the age-specific enrolment ratios for primary, secondary and higher education.

School survival expectancy (SSE): The SSE for a child of a certain age (the reference age) is defined as the number of years of schooling which a child of that age, *who is already at school*, can expect to receive in the future. It is the ratio between the sum of the age-specific enrolment ratios for primary, secondary and higher education and the enrolment ratio at the reference age (for more details about the mode of calculation, see Statistical notes in the same Report and UNDP, *Human Development Report 1995*, Technical Notes).

	Male	Female	Total
Field A	220	60	280
Field B	20	100	120
All fields	240	160	400

The composition by sex of the total enrolment in all fields taken together (400) is 60 per cent male (240) and 40 per cent female (160). If the total enrolment in field A (280) and in field B (120) were also to be 60 per cent male and 40 per cent female, then the enrolment in each of these fields would be:

	Male	Female	Total
Field A	168	112	280
Field B	72	48	120
All fields	240	160	400

To obtain this new composition, 52 males in field A would need to 'move' into field B and 52 females in field B would need to 'move' into field A. Of the grand total of 400 persons enrolled, 104 would need to change fields. In this case the sex segregation index (GSI) is equal to:

$$GSI = \frac{\text{Number of persons who have to change fields}}{\text{Total enrolment}} = \frac{104}{400} = 26\%$$

It should be stressed that the calculation of the number of persons who would need to change field is based on the percentages of males and females in the total enrolment for all fields taken together.

It follows that the index is not a measure of the overall gender disparity in access to, or participation in a particular level of education, but rather a measure of the concentration of men and women in specific fields, *for a given overall gender distribution*.

Towards gender-equity-sensitive indicators (GESI)

Absolute achievement versus gender parity

In making inter-country comparisons, we want to take into account at the same time overall (both sexes) achievement and gender inequalities (gender gaps and parity indices). If the overall value is the same, more inequality will evidently indicate a worse social situation. But the question is more complex when the overall or mean levels of achievement are different. In particular, in measuring progress, should the criterion be a reduced gender disparity or a higher absolute achievement? In Haiti, for instance, the literacy rate is 43 per cent, with 46 per cent for males and 40 per cent for females. Should this social outcome be judged worse than that of Chad, which has an overall literacy rate of 45 per cent, with 59 per cent for males and 31 per cent for females? Haiti has a lower literacy rate than Chad, but it also has less gender inequality.

To answer this type of question, synthetic indicators have been proposed which integrate the gender-equity dimension in the measure of absolute achievement. UNDP has recently developed a gender-equity-sensitive indicator (GESI), which utilizes the *harmonic mean* between the male and female indicators.[6] The harmonic mean takes into account both the value of the overall ratio and, to a certain extent, the disparity between males and females.

BOX 5.2: EXAMPLES OF GESI CALCULATION

In the above-mentioned examples of literacy rates in Haiti and Chad, the calculation of the GESI would be:
For Chad:

$$\frac{1}{GESI_{lit}} = \frac{0.5}{0.59} + \frac{0.5}{0.31} = 0.847 + 1.613 + 2.459$$

where 0.5 is the approximate share of males and females on total population.

Therefore:

$$GESI_{lit} = \frac{1}{2.459} = 0.41$$

For Haiti:

$$\frac{1}{GESI_{lit}} = \frac{0.5}{0.40} + \frac{0.5}{0.40} = 1.087 + 1.250 = 2.337$$

Therefore:

$$GESI_{lit} = \frac{1}{2.337} = 0.43$$

Source: UNESCO, 1997.

6. See UNDP, 1995.

Thus if we calculate the GESI instead of the arithmetic mean, in the above example Haiti would rank higher than Chad despite the fact that the overall (both sexes) literacy rate is higher for the latter.

Correlation between education and other socio-economic factors

Various socio-economic variables, such as income and fertility, are supposed to account to a certain extent for the observed variation among countries (or provinces or regions) in the literacy rates and enrolment of girls in first- and second-level education.

The techniques of regression and correlation enable relationships between pairs of variables to be identified and quantified. These techniques can used be more frequently in the study of gender disparities, especially as most spreadsheet software nowadays incorporates such analytical facilities.

BOX 5.3: CALCULATION OF LINEAR CORRELATION COEFFICIENT

It may be recalled that, given two distributions x and y, if we divide the covariance of x and y by the standard deviation of the x and the standard deviation of the y distribution, and finally average the results, we obtain the coefficient of linear correlation, r:

$$r = \frac{\Sigma(x_i - x)\,(y_i - y)}{\sqrt{\Sigma(x_i - x)^2\,(y_i - y)^2}}$$

This expression has the extremely important property that r is a pure number with no associated units and

$$-1 \leq r \leq +1$$

where r = +1 indicates perfect positive linear correlation;

r = -1 indicates perfect negative linear correlation, and

r = 0 indicates zero linear correlation.

It should be recalled that positive or high correlation between two variables, x and y, does not of itself demonstrate that x causes y or that y causes x (or indeed that they are both caused by a third factor).

Example 10. Coefficients of correlation between fertility, income, adult illiteracy, GER, percentage of female teachers and GPI, 1992.

Using regression and correlation techniques, relationships between pairs of variables are identified and quantified, with a view to studying gender disparities. The coefficients of correlation are presented among:

- the total fertility rate
- real GNP per capita
- male and female adult illiteracy rate
- male and female GER at primary and secondary education
- percentage of female teachers in primary education
- GPI for GER of primary and secondary education.

Gender indicator activities at the international agencies

European Commission/Eurostat

Women and science indicators – *She Figures 2003*

She Figures is the result of several years of work of the EU's Women and Science Group, in cooperation with Eurostat and the national statistical correspondents of the Helsinki Group (presented in Chapter 1), to develop a coherent system of harmonized gender-specific indicators. The work has so far involved two data-gathering exercises and ongoing technical and analytical assessments of the data. Data cover the EU Member States (15 countries in 2001) and associated non-EU countries,[7] some of which have since joined the EU as full members. Depending on countries, time series start in 1997. A summary of the table of contents is presented in Figure 5.3.

European Commission: *Women in Industrial Research* (WIR)

For years it has been well known that the proportion of women is higher than that of men at the lower levels of university systems, in both the student body and the

7. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

faculty; but that higher up in career hierarchies these proportions change as women are surpassed by their male colleagues. The situation appeared to be more or less the same in public sector S&T and R&D institutions, but little was known about women's participation in industrial R&D. Two recent and comprehensive EC reports, *Women in Industrial Research – A Wake Up Call for European Industry* and *Women in Industrial Research – Analysis of Statistical Data and Good Practices of Companies* (EC, 2003a-b), have shed light for the first time on women's participation outside the academic and public sectors. The studies confirm that women are still under-represented in industry, especially at the highest management levels, but show that private enterprises have recently started recruiting more young female scientists and engineers. As shown in Figure 5.4, the two studies analyse the situation in depth, touching upon a wide range of issues to explain current equity problems while also making recommendations to increase equity in the industrial sector. They also contain extensive and complete reference lists of similar work undertaken worldwide.

European Commission/Eurostat: *Statistics on S&T in Europe*

While the above two publications are gender-focused, the gender dimension is also addressed in the standard EC publications on S&T/R&D. Figure 5.5 presents extracts from the table of contents of the fourth chapter of the EC/Eurostat publication *Statistics on S&T in Europe – Data 1991–2002* (EC, 2004).

The third chapter is limited to 'R&D personnel', with only one gender-specific item: 'Figure 9c: Percentage of female researchers in FTE, all sectors and BES [business enterprise sector], EU-15, Candidate Countries, Iceland and Norway – 2001.'[8]

UNESCO and the UIS: Sources and new publications

The *Statistical Yearbook*

For many years, the principal sources of worldwide education, culture and science statistics were UNESCO's *Statistical Yearbook,* with some series – but not all – disaggregated by sex. The most recent issue of the *Yearbook* was published in 1999.

The *Global Education Digest*

After the creation of the UIS in Montreal, education statistics for all ISCED levels have been presented in the UIS's annual *Global Education Digest*: *Comparing Education Statistics in the World* (most recent issue May 2005). In contrast to the *Yearbooks,* the *Global Education Digest* contains some analysis of the data. All these series and their sub-groups are now, with one or two exceptions, systematically disaggregated by sex. Data, as a rule, indicate either M (male) or F (female) separately or MF combined, with a 'percent F' (indicating the female percentage share of the MF total). As in the foregoing, GPI refers to 'Gender Parity Index' in a number of Digest tables. The rationale for and the use of some of these rates, ratios and indices – with practical examples – are described above (see the guidelines from *Gender-Sensitive Education Statistics and Indicators*). Some of the information presented below is collected in line with the guidelines.

These short time series indicate increasing participation in education (in both absolute and relative terms) of women and girls, in all regions of the world and in all disciplines and at all levels of education. However, as shown in other series, women and girls are still seriously over-represented in illiteracy series. The *Global Education Digest* observes that, while there are overall signs of progress in terms of gender parity at the primary level of education, the gap is still noticeable at the secondary level. Reaching MDG 3 – to eliminate gender disparity in primary and secondary education by year 2005, and all levels by 2015 – will be problematic, and attaining the same targets at higher levels a long-term challenge. According to the Digest, some 56 per cent of the world's primary school-age population still lives in countries without gender parity and, at the upper secondary level, this number increases to 87 per cent.

8. More information on European work in the field of R&D/S&T may be found on the following websites: Eurostat data is available at http://www.europa.eu.int and http://www.europa.eu.int/comm/eurostat. Eurostat also provides a CD-ROM, *Statistics on Science and Technology*, which contains the most up-to-date data in the fields of government budget appropriations or outlays for R&D (GBAORD), R&D expenditure and personnel, HRST, and employment in high-technology and knowledge-intensive sectors.

Figure 5.3: *She Figures 2003* – Summary of tables and figures

Abbreviations in tables

BES	Business enterprise sector
FTE	Full–time equivalence
GOV	Government sector
HC	Head count
HES	Higher education sector
HRSTE	ST – qualified persons in the labour force
HRSTO	persons working in professional or technicians occupations
HRSTC	Persons falling into both these categories
NACE	Nomenclature of Economic Activities (of the EU)
PNP	Private non-profit sector

Source: EC, 2003c.

Figure 5.4: ***Women in Industrial Research*: *Analysis of Statistical Data and Good Practices of Companies* (2003b) – Table of contents**

Source: EC, 2003b.

Figure 5.5: ***Statistics on Science and Technology in Europe – Data 1991–2002*** **– Chapter 4, tables and figures**

* Selected fields of study = science, engineering, manufacturing and construction

** Varieties of manufacturing = high-tech, medium high-tech, medium low technology, low technology

Source: EC/Eurostat, 2004.

The 2005 edition of the *Global Education Digest* presents sex-disaggregated tables, with related variables, summaries of which are presented in Figure 5.6 below. These tables on early enrolments of pupils and teaching staff are constructive for long-term planning, although Tables 7–10 appear to be of particular interest to this toolkit for analysing the current situation of flows and stocks of qualified STP.

UNESCO R&D statistics

Besides collecting education statistics and indicators, the UIS also collects S&T statistics (limited to R&D data) and culture and communication statistics. For several years, the R&D series have been collected fully in line with the OECD *Frascati Manual* guidelines, with intensified interest in sex-disaggregated statistics (HC and FTE). Since the discontinuation of the *Statistical Yearbooks*, selected R&D data have been issued in regional reports and in the *UIS Bulletin on S&T Statistics*.[9]

OECD education statistics and indicators

Education at a Glance

Since the early 1990s, the Directorate for Education of the OECD – in close cooperation with the education-linked OECD institutions and programmes mentioned below, and with a large number of experts in lead countries – has continued its earlier collection of raw education statistics for transformation into sophisticated education indicators. These indicators focus on human and financial resources invested at all levels of education and on the returns of the same investments, for instance in term of learning outcomes (education attainment of the population, students' literacy performance in various fields of study, or earnings related to levels of education). The principal purpose is to enable countries to compare their performance to other countries and allow the analysis of education systems across countries. The material is issued in the annual publication *Education at a Glance: OECD Indicators,* which contains a rich combination of qualitative and quantitative information (statistics and indicators, graphs, charts and analysis). Where relevant, breakdowns by sex are now more or less systematic in tables as well as in analytical comments (see Figure 5.7).

The following groups, which are attached to the OECD Directorate for Education, are closely linked to the statistical and analytical indicators work:

CERI – The Centre for Education Research and Innovation undertakes investigations in a wide range of areas concerning trends and innovation in education.

IMHE – The programme on Institutional Management in Higher Education addresses governance and other strategic issues affecting universities and other tertiary institutions.

PISA – The Programme for International Student Assessment undertakes, every three years, a survey of the knowledge and skills of 15-year-olds in some industrialized countries, measuring the extent of students' acquisition of the knowledge and skills essential for full participation in society. Besides OECD countries, in cooperation with the EC and UNESCO the programme includes a number of non-OECD and industrializing countries. Major policy messages are addressed in the annual PISA *Education Policy Analysis* publications. Besides the thirty OECD Member Countries (2005), a number of other countries representing all continents participate in the OECD/UNESCO World Education Indicators (WEI) programme as well: Argentina, Brazil, Chile, China, Egypt, India, Indonesia, Israel, Jamaica, Jordan, Malaysia, Paraguay, Peru, Philippines, Russian Federation, Sri Lanka, Thailand, Tunisia, Uruguay and Zimbabwe.

Whereas much of the collection of education statistics is becoming standardized with a view to building up longer time series – for instance, to follow cohorts through educational systems – the OECD work is also receptive to emerging needs of governments and citizens. Over time, successive *Education at a Glance* reports have focused on a range of policy issues. The reports are accompanied by timely *Education Policy Analysis* studies, which discuss themes of key importance to governments, the general public and education specializts. References to some recent titles may be found at the bottom of Figure 5.7.

OECD education publications/databases

For more information on the OECD Education Statistics and Indicators Databases, see www.oecd.org/education,

9. More information on general UIS activities and statistics are available at http://www.uis.unesco.org.

Figure 5.6: *Global Education Digest 2005* – Tables

Table 1. Pre-primary education, ISCED 0. Enrolment and teaching staff
Education system: entrance age and duration
Enrolment: 1998/99 and 2002/03 – *MF, %F*, % private
Gross enrolment ratio: 2002/03: *MF, M, F, GPI*
Net enrolment rate 2002/03: *MF, M, F, GPI*
Change 1998/99 to 2002/03
Teaching staff 2002/03: *MF, %F*
Trained teachers 2002/03: *(%) MF, M, F,*
Pupil/teacher ratio 2002/03

Table 2. Primary education ISCED 1. New entrants
Education system: compulsory education age range; primary education: entrance age and duration
New entrants 2002/03: *MF, %F*
Gross (apparent) intake ratio 2002/03: *MF, M, F, GPI*
Net intake rate 1998/99 and 2002/03: *MF, M, F*
Change 1998/99 to 2002/03
New entrants to primary education with ECCE experience (%) 2002/03: *MF, M, F*

Table 3. Primary education, ISCED 1. Enrolment and teaching staff
Enrolment 2002/03: *MF, %F, %Private*
Gross enrolment ratio 2002/03: *MF, M, F, GPI*
Net enrolment rate 2002/03: *MF, M, F, GPI*
Change 1998/99 to 2002/03
GPI 1998/99 and 2002/03
Teaching staff 2002/03: *MF, %F*
Trained teachers 2002/03: (%) *MF, M, F*
Pupil/teacher ratio 2002/03

Table 4. Measures of progression and completion in primary education, ISCED 1
Total numbers of repeaters 2002/03: *MF, %F*
Percentage of repeaters 2002/03: *MF, M, F*
Survival rate to Grade 5, 2001/02: *MF, M, F*
Survival rate to last grade 2001/02: *MF, F, GPI*
Gross intake ratio to the last grade of primary education 2002/03: *MF, M, F, GPI*
Expected gross intake ratio to the last grade of primary education 2002/03: *MF, M, F, GPI*
Gross primary graduation ratios 2002/03: *MF, M, F, GPI*
Expected gross primary graduation ratio 2002/03: *MF, M, F, GPI*
Transition rate from ISCED 1 to ISCED 2 (general programmes), 2001/02 to 2002/03: *MF, M, F, GPI*

Table 5. Secondary education, ISCED 2 and 3. Enrolment and repeaters
General secondary education: entrance age, duration
Enrolment 2002/03: all programmes *MF%*, general programmes *MF, %F*; enrolment in technical and vocational programmes (without gender breakdown)
Gross enrolment ratio, lower, upper secondary, all programmes 2002/03: *MF, M, F, GPI*
Gross enrolment ratio total secondary, all programmes 2002/03: *MF, M, F, GPI*
Net enrolment rate total secondary 2002/03: *MF, M, F, GPI*
Percentage of repeaters, total secondary, general programmes 2002/03: *MF, M, F*
Change 1998/1999 to 2002/2003

Table 6. Secondary and post-secondary non-tertiary education, ISCED 2, 3 and 4. Teaching staff and post-secondary non-tertiary enrolment 2002/03
Teaching staff: total secondary, lower secondary, upper secondary – *MF, %F*
Trained teachers, (%) total secondary: *MF, M, F*
Pupil/teacher ratio: total secondary, lower secondary, upper secondary
Post-secondary non-tertiary education (ISCED 4) enrolment: *MF, %F*

Table 7. Upper secondary (ISCED 3) graduation and entry to tertiary (ISCED 5) education, 2002/03 (selected countries)
Upper secondary gross graduation ratio: for ISCED 3A (preparation for direct entry into ISCED 5A education), ISCED 3B (preparation for direct entry into ISCED 5B education), 3A (no direct access to ISCED 5 excluding short programmes) – *MF, M, G, GPI*
Gross entry ratio to tertiary education for ISCED 5A, 5B
Upper secondary gross graduation ratio for ISCED 3A, 3B, 3C – *MF, M, F, GPI*
Gross entry ratios to tertiary education for ISCED 5A, 5B – *MF, M, F, GPI*

Table 8. Tertiary education, ISCED 5 and 6. Enrolment and teaching staff
Total enrolment 2002/03: *MF, %F*
Gross enrolment ratio 1998/99 and 2002/03: *MF, M, F, GPI*
Distribution of students (%) 2002/03: by ISCED 5A, 5B, 6
Female students 2002/03 by ISCED 5A, 5B, 6
Gross graduation ratio ISCED 5A first degree 2002/03: *MF, M, F, GPI*
Teaching staff 2002/03: *MF, %F*

Table 9. Foreign students in tertiary education by hosting country and continent of origin, 2002/03 (countries having more than 1000 foreign students)
Number of foreign students: *MF, %F*
Foreign students as % of tertiary education
Continent of origin: Africa, North America, South America, Asia, Europe, Oceania, Unspecified

Table 10. Tertiary education, ISCED 5 and 6. Graduates by field of education, 2002/03
Total number of graduates: *MF, %F*
Graduates (*MF, %F*) by fields of education as % of total: education; humanities and arts; social science; business and law; science; engineering manufacturing and construction; agriculture; health and welfare; services; not known or unspecified.

Table 11. School life expectancy (approximation method), 2002/03
Pre-primary education ISCED 0: *MF, M, F*
Primary and secondary education ISCED 1–3: *MF, M, F, GPI*
Primary to tertiary education, ISCED 1–4, 1998/99, 2002/03: *MF, M, F, GPI*

(Tables 12 and 13 are devoted to education expenditures)

www.oecd.org/statistics and www.oecd.org/publications. Information on sources and methods and technical notes concerning *Education at a Glance 2004* is available at www.oecd.org/edu/eag2004 (electronic format only).

OECD Education Online Database

Selected reports and publications related to OECD educations indicators work:

- *Education at a Glance 2003*, 'Coding of Missing Data'
- *Classifying Educational Programmes: Manual for ISCED-97 Implementation in OECD Countries* (1999)
- *Teachers for Tomorrow's Schools: Analysis of the 2000 World Education Indicators* (2001)
- *Financing Education: Investments and Returns – Analysis of the World Education Indicators* (2002)
- *PISA 2000 Technical Report* (2002)
- *Manual for the PISA 2000 Database* (2002)
- *PISA 2003 Data Analysis Manual*
- *OECD Handbook for Internationally Comparable Education Statistics: Concepts, Standards, Definitions and Classifications* (2004)
- *Education Policy Analysis* (2004)
- *First Results from PISA 2003* (2004).

OECD S&T indicators and R&D statistics

Currently, approximately 80 per cent of R&D in the world is carried out in the OECD countries. The databases of the OECD Directorate for Science, Technology and Industry contain detailed long-term series of R&D expenditures and personnel, for national totals and the four sectors of performance (presented above in Chapter 4). The R&D standard series go back to 1981 and underpin psolicy-related analytical work, particularly with respect to links between technology, competitiveness and globalization. However, even if the OECD *Frascati Manual*, from the outset, suggested the collection of data on R&D personnel by sex as a possibility, it is only quite recently that this information has been requested as a major criterion, and rather few sex-related statistics are available in the OECD S&T databases.

Only one of the 76 or so standard tables in the hard copy of the OECD's biannual *Main Science and Technology Indicators* (MSTI) refers to gender: 'Woman researchers as a percentage of total researchers (based on HC)'. The electronic version of the MSTI presents absolute HC data in all 138 indicators for the national and sector[10] totals plus the percentage shares in each of these totals of women researchers.

Gender data and indicators at higher levels

Undergraduate retention of women students

Case study: Recruiting and retaining high-achieving female students in undergraduate natural science and engineering disciplines (Gilbert and Pomfret, 1995)

A study was undertaken for the Canada Scholarships Program (CSP) in support of one of its objectives: to encourage more outstanding women students to pursue science and engineering education. The report examined the role of preference motivation and achievement in gender tracking in undergraduate university programmes, particularly natural science and engineering disciplines.

The gender-tracking research undertaken employed a four-year longitudinal database augmented by questions designed specifically to examine the discipline choices of undergraduate women students and the achievement of women in science and engineering disciplines. The quantitative survey research data were complemented by qualitative in-depth interviews with high-achieving women, both those who remained in and those who left science and engineering disciplines included in the CSP.

The analysis first examined recruitment, or the relationship between sex and discipline choice as it occurred between the natural science and engineering disciplines and other disciplines. The report examined the attitudes, values and experiences which lead to gender tracking in university programmes. The psychological/motivational factors underlying these discipline choices were investigated by comparing influences across and within educational programmes. Information was provided on the factors that underlie choices by women who enrol in science-related disciplines and women who enrol in disciplines traditionally selected by women. Similarly,

10. Business enterprise, government and higher education.

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Source: OECD, 2004.

psychological/motivational differences between males and females in the natural sciences and engineering disciplines were investigated. The analysis seeks to provide information on why female students choose certain types of educational programmes and not others, and on how they differ from male students within those programmes.

A second focus was on the relationship between gender and achievement within natural science and engineering fields. The analysis explores the consequences of gender tracking for student outcomes and achievement. Specifically, it asks: if there are significant differences between the women and men who enter mathematics, science and engineering programmes at university, how might these gender differences affect their persistence, completion and success in those disciplines? Similarly, are there differential experiences for women and men at university which may alter their choice of educational destination? The gender and achievement analysis examines factors such as marks and other academic outcomes, academic pursuits, contact and satisfaction with faculty, and educational and career aspirations.

The gender-tracking research in this study combined secondary data from an ongoing, major longitudinal study of student progress and student attrition with new data specifically designed to measure factors associated with the recruitment and retention of women in university science and engineering disciplines.

In fall 1986, all new first semester students at the University of Guelph were surveyed, via a questionnaire, on their background characteristics and their aspirations and expectations regarding university life (Questionnaire 1, fall 1986, N = 19037). These same students were contacted again after two semesters, and data were obtained concerning actual university experiences, problems, learning and knowledge acquisition along with various student satisfaction measures (Questionnaire 2, winter 1987, N = 1626).

In fall semester 1987, the same cohort of students was again contacted for an even more detailed evaluation of how well studies were progressing in terms of knowledge and skills acquisition, and of intellectual development (Questionnaire 3, fall 1987, N – 906).

In winter semester 1988, all students who had left the University of Guelph between fall 1986 and winter 1988 who could be found were contacted for a telephone interview to ascertain the exact locations of the 'leavers' within the post-secondary system or the labour force and the reasons for the change of plans.

In winter semester 1990, students received a final questionnaire that measured prior-to-graduation educational outcomes and consequences.

The study design permitted comparisons between 'stayer' and 'leaver' groups or, for that matter, comparisons among those required to withdraw, 'persisters' and 'leavers', based on different experiences at the University of Guelph and on social background characteristics and gender. A wide range of behavioural and attitudinal variables were contained in the overall data set, including items from the student information system. Response rates to the total population surveys were good to excellent.

The focus of the initial research was on student attrition and educational outcomes, and results have been reported in several articles and papers (Gilbert, 1989; Gilbert and Evers, 1989; Gilbert, Evers and Auger, 1989; Gilbert and Auger, 1988).

The longitudinal data document gender as an important and pervasive factor in student expectations, progress, programme selection and satisfaction. In particular, women display greater levels of motivation to attain undergraduate degrees, perform better academically in high school, and initially in university, than men, yet have lower estimates of their own academic ability and potential for graduate study than do men.

For the gender-tracking project, a specific set of new questions was inserted in Questionnaire 4 (winter 1990) to measure educational experiences and outcomes, general values and specific attitudes, and to capture, retrospectively, the reasons and encouragements (role of significant others, role models, etc.) for the selection of science and non-science programmes. Career aspirations and overall assessments of students' experiences were also measured.

Qualitative in-depth interviews were conducted to supplement the quantitative survey data. All female high achievers who transferred out of science and engineering disciplines and an equivalent, randomly selected sample of high-achieving female 'persisters' were targeted for detailed interviews concerning reasons, experiences, attitudes about science programme features and gender-identity self-descriptions. Interviews were conducted with twenty of the twenty-eight women high achievers who transferred out of Canada Scholarships Programme (CSP) disciplines and with twenty-seven of the sample of thirty women high achievers who remained in CSP disciplines.

Data collection instruments

Disaggregation and reporting of data by sex is standard procedure for many of the basic surveys of education participation in the US. These surveys were conducted by the Department of Education and by the NSF's Division of Science Resources Studies (SRS); they track enrolment in educational institutions at undergraduate or graduate levels and formal outcomes of education.

The surveys collect information from two types of respondents: institutions and individuals. In most cases the surveys are voluntary. As a result an important aspect of obtaining high-quality data is taking steps that will help obtain a satisfactory response rate. This rate has been set at 80 per cent as a minimum for government surveys if results are to be published.

Institutional surveys

Several steps contribute to high response rates, including:

- involving representatives of respondents at early stages in the survey-planning process
- providing advance notification that information will be collected
- demonstrating to the institution the value of maintaining the information
- showing the institution the usefulness of having access to similar information from peer institutions.

Early involvement of potential survey respondents lets those planning the surveys understand the record systems at institutions, which vary widely. It is also important to know what information is maintained at institutions as administrative records, such as student records including sex, birth data and level of enrolment. Additional data is of particular interest, such as demographic characteristics, student support or transcript data on courses completed, all of which may be important to data analysis examining causes of gender differences.

A third factor affecting the willingness of institutions to supply data voluntarily is the provision of access to comparable information from other institutions, particularly as comparing data provides valuable information to create benchmarks for measuring one's own performance. A central agency can maintain high response rates by giving this information back to respondents at no cost. The good will generated from 'data sharing' can be substantial.

Staying in tune with the issues plays an important role in planning data collection. Expansion of a straightforward survey of enrolments provides an example. An SRS survey of graduate students in science and engineering in the US was originally intended to provide counts by sex of students receiving financial support from the NSF. When racial and ethnic group enrolments became important to the study of equal access to graduate education, a section of numbers on students in each of several broad racial and ethnic groups was added. Within the last five years, the race and ethnicity survey was expanded to include gender considerations. Before changing the survey, responding institutions were asked if the information could be provided.

Surveys of individuals

Two factors are useful in obtaining high response rates on surveys of individuals:

- Guarantee to the respondent that any information provided will be held in confidence and used for statistical purposes. That is, the identity of the respondent will not be revealed. Access to all data on individuals is carefully controlled. Those wishing to use datasets with continuing records of individuals must sign agreements regarding the handling of the records and analyses resulting from their tabulations; violations are punishable by law.
- Placement of questions regarding potentially sensitive items, generally personal characteristics of the respondents. Questions on marital status, number of dependents, presence of a disability and need to choose a job based on family situation have been shown to be important in analysing gender differences. Research has shown that people are more willing to provide information about themselves if the instrument has secured their support for the data requested, that is, if they are able to identify with the issues addressed (such as satisfaction with work of discussion of work assignments). In such a case they may be more willing to provide a profile of themselves that includes such items. This factor is equally important as researchers and policy-makers identify issues that may have

Collecting gender-disaggregated data on participation in science and engineering in the United States (Golloday, 1998 and NSF, 1998)

an impact on gender differences in science and engineering participation.

Additional variables not immediately related to gender may nonetheless be important to the analysis of gender differences. In the case of institutional surveys, such factors as full- or part-time enrolment status and discipline field of study or completion may differ by sex. Data from individuals that are important to analyses may include salary and type of employer, as well as those variables already identified.

Data presentation

Tables

Tables can be designed to present results highlighting a particular aspect of the data, such as comparisons of women and men, changes over time, and distributions across discipline areas. For example, in the case of time trends, parallel columns in the same table showing data for men and women may make a point more easily than would separate tables for men and women. The information content of the data may also be expanded by combining data from multiple sources, such as population counts and earned academic degrees. The number of degrees in science and engineering fields related to the population of an age group – representative of the age group for that degree level – provides a measure of participation that 'corrects' for differences in population size.

Text

In presenting information, words must be chosen that keep the presentation of the information above reproach. The objectivity of the information should not be questioned by debates on its significance.

The responsibility of the data collector to provide information, including qualifiers that indicate confidence levels that can be ascribed to the data while not taking the next step to policy recommendations, is key. Such questions as 'Is progress fast enough?' or 'Is more possible?' or 'What range of differences is acceptable?' are not answered in SRS publications.

Participation of women in S&T careers

Research and university positions

Case study: The situation of women in the S&T sector of Latin America (Kochen et al., 1998)

The analysis of the situation of women in the S&T professions (research) undertaken by the Argentine Network of Gender, S&T (RAGCYT) suggests several indicators to address 'gender differences in the undertaking of scientific-technological formation, research and practice' in an attempt to highlight the 'real situation' of women not revealed by traditional indicators based on sex disaggregation. The indicators suggested are:

- *Sex-related analysis of age* permits an evaluation of the changes in access to the different levels of a sector, with time frame.
- Sex-related analysis of *age and number of children in relation to the achieved level or status in the institution hierarchy* indicates differences in job-related advances with respect to maternity/paternity.
- Analysis of the *age-related hierarchical levels* achieved by women indicates recognition of their status in the system.
- Analysis by *scientific discipline* permits scoring fields as feminized, equalized and masculinized.
- Analysis by discipline in relationship to *age and hierarchical status* allows visualization of the situation of women already in the sector.
- Longitudinal analysis by *discipline related to age and hierarchical status* allows the comparison of the differences in professional progress between women and men.

Tracking the participation of women in S&T industry

Case study: Measuring progress for women in SET using benchmarking (Inch et al., 1993)

Benchmarking is a tool that industry can use to determine whether it is making any progress in the recruitment, retention and career advancement of women scientists, engineers, technicians and technologists. It is a continuous

process of measuring products, services and practices against competitors or those companies recognized as industry leaders, and could be used as a tool to improve human resource management processes.

Benchmarking has been defined as 'a continuous process of measuring products, services, and practices against competitors or those companies recognized as industry leaders' (Camp, 1989). The concept can be adopted as a tool to improve human resource management processes within specific industrial sectors and even on a cross-sectoral basis. A neutral third party collects selected data from a selected number of firms, compiles it and then distributes it back to participating firms, whose confidentiality is protected. Gaps are identified, future performance goals are set, and action plans are implemented to monitor progress.

The first phase included the development of benchmarking options, that is, objective and practical methods to measure and report on progress in recruitment, retention and career advancement of women scientists, engineers, technicians and technologies. The second phase comprized implementation and testing of these indicators in an industry sector.

Phase I

Identification and analysis of existing relevant sources of quantitative and qualitative information on the status of women in SET in the workplace, including:

- databases and research on employment status, responsibility levels, salaries and promotion rates of women and men
- private- and public-sector policies, procedures and programmes affecting the recruitment, retention and career advancement of women in these occupations
- research on attitudinal barriers to women's full participation in the workforce.

Sources reviewed or consulted included:

- federal and provincial government departments responsible for employment equity and the status of women
- employee organizations, such as professional associations and unions
- industry and employer associations
- organizations for women in SET
- independent policy and research institutions.

Gaps in knowledge were identified and ways to use existing information and data to measure progress in the workplace were examined. Validity, reliability and cost-effectiveness of the information being considered as indicators of employment status was assessed.

Doable and practical methodologies for a benchmark study were developed, with consideration of various options for small, medium and large companies. The views and practical advice of key experts from the private and public sectors were sought, particularly their reaction to the measurement variables and specific methodologies under consideration. Experts included:

- individuals responsible for managing or administering employment equity programmes
- human resources specialists
- union officials
- representatives of interests of women in SET.

The various options were further refined, and the design, action plans and costs of each option developed for the benchmark study.

As a result of this process, the following objectives and measurements were decided:

1. Objectives

To examine three areas:

- stock and flow data on the representation, promotion and retention of women in S&T jobs at all levels, including senior management
- existence and enforcement of supportive policies and programmes (e.g. proactive recruitment programmes, unbiased selection processes, women's advisory committees, career-development programmes, sexual harassment policies, and work and family policies);
- existence of attitudinal and systemic barriers to the full participation of women in S&T occupations in the workplace.

2. Measurements:

- numbers on representation of women and men engineers, technicians and technologists
- hiring, training and workforce adjustment procedures, practices and programmes
- availability of career development and succession planning programmes for men and women

- presence of supportive policies, procedures and programmes
- working conditions
- mechanisms to monitor and report on progress.

Phase II

Phase II was not completed. The objectives were to:

- implement an action plan to measure the status of women in S&T occupations in an industry sector
- assess the effectiveness of the benchmark study
- develop options for repeating the benchmark study to measure progress over time
- adopt of the benchmarking tool for use in other industrial sectors
- develop of a checklist for industry for internal use to measure the outcomes of their policies, practices and procedures.

Other OECD S&T gender-related work

Case study: 'Positive measures' identified in the OECD study on women in S&T (1988/90)

In 1988/90, with support from the NSF, the OECD undertook an extensive study on women in R&D/S&T.

In response to concerns about risks of shortages of skilled personnel, a workshop was organized on the theme 'Assessing the Availability of and Need for Research Manpower', followed by a programme to examine possible counter-measures. It was suggested that more effort be focused on policy measures to increase the supply of skilled workers, in particular by examining the past, current and potential participation of women in the S&T workforce.

A significant volume of (essentially education) statistics was gathered from the Member Countries. It was found that absolute comparisons between countries, at a given moment in time (snapshots), were less suitable for analytical comparisons than longitudinal studies (trends).

Specific attention came to be given to temporary or permanent withdrawals of women from university, especially to drop-out rates for women in the S&T fields of study and from S&T occupations. An inventory was made of different types of programmes at various levels of the national S&T and education systems to promote the attraction of women to and their retention in S&T. The inventory, based on a large number of sources, covered the whole age span of girls and women, from pre-primary school to practising and even retired female scientists and engineers.

The work gave rise to a number of internal discussions at the OECD and in Member Countries, but it was finally decided that, in spite of its evident policy interest, the final report did not meet traditional OECD quality standards. It was not released for general distribution. However, it was one of the first complete international studies done in the field of gender policy, and the various attraction and retention programmes suggested are still relevant.

The following is a selection of the attraction and retention programmes identified in the study:

At the pre-primary school level:

- reduction of gender-biased distinctions in child activities
- promotion of natural S&T curiosity
- technical nurseries
- practical information.

At primary school levels:

- S&T classes
- gender-neutral teaching materials and physical environment
- pedagogic techniques and S&T materials
- teacher-parent communications
- teacher training in mathematics and science
- male/female teacher balance
- science exhibits
- S&T centres, museums.

At secondary and upper-secondary school levels:

- obligatory mathematics, science and engineering classes
- special mathematics and science classes
- information on S&T opportunities and careers
- discussions with practising scientists and engineers
- visits to laboratories, design and production installations
- conferences and courses to promote higher education choices
- introductory courses to undecided students
- parent-student-teacher meetings

- financial aid (student support mechanisms)
- remedial S&T courses
- second and third opportunities to obtain mathematics and scientific qualifications
- communications and entertainment featuring S&T
- integration of social/gender awareness with S&T studies
- teacher training and instructional materials
    - unisex (female) study groups and classes
    - counselling activities – toward sex-stereotyping avoidance
    - technical apprenticeships
        - part-time study
- creation of female mentor support groups
- vocational programmes
- minimum quotas in all study tracks
- technical employment assistance.

At post-secondary school education level – lower stages of higher education:

- financial support (scholarships, loans, grants)
- creation of female/male support groups
- female study groups
- workshop and laboratory experience
- teacher training
- part-time and short-course studies
- encouraging male interest in normally female-pursued studies
- role models
- labour market counselling
- introductory courses
- information and related materials.

At the level of advanced higher education:

- financial support (loans, grants, fellowships)
- flexible study/work/family care activities
- social and psychological encouragement
- research mentor counselling activities
- promotion of labour market possibilities
- elimination of abuse
- female participation in selection processes
- equality of facilities and human resource use
- creation of temporary research positions
- university associations for female researchers.

Promotional measures at the level of employment:

- transparency in selection criteria and of decision-making
- non-prejudicial assignments
- promotional opportunity
- recycling from non-traditional occupations
- leadership and management opportunities
- flexible and part-time work
- equality of remuneration
- organization representation
- professional society involvement and publication
- examination of male colleague sexist behaviour
- internship programmes
- in-service training
- networking with female professionals
- childcare facilities
- changes in organizational practices
- recruitment of women
- updating courses
- job-sharing
- re-insertion into professional practice
- affirmative action (legislative and judicial) initiatives.

Women's participation in S&T decision-making

Case study: Women leaders in Latin American universities (Bond, 1997)

A study undertaken by Sheryl Bond for the UNESCO Special Project on Women, Higher Education and Development examined the question of why there are so few women in senior administrative positions in Latin American universities. It looked at:

- origins of leadership
- career development
- motivational factors
- choices
- perceptions
- expectations of women who currently hold posts of significant responsibility in Latin American universities and of whom leadership is expected.

Data were collected by means of a quantitative survey, in-depth interviews and round-table discussion. An extensive survey was distributed in the fall of 1995 to a random sample of 525 women and men in 44 of the

member institutions of the Inter-American Organization for Higher Education (IOHE). A total of 99 women and 108 men from 23 institutions in the four regions of Latin America returned the survey. To compare women's experience of preparing for and holding positions of leadership to men's, men as well as women were included in the study.

For the purposes of the study, academic administrative posts included: Rector (a), Vice-Rector (a), Decano (a), Vice-Decano (a), and Director Academico (a). Professional administrative posts included: Vice-Rector (a), Secretario (a), Director General (a), Coordinador (a) and Director Administrativo (a).

While the survey was the foundation of the study, important qualitative analyses of the findings were drawn from round-table discussions involving nearly 100 people of both sexes. Because having such a large number of women in the study was important for the generation of reliable findings, 45 per cent of the participants were women, which is a much higher fraction of women than exist in the general population of university administrators.

An understanding of the reasons for the continuing under-representation of women is far more difficult than has been thought. A comprehensive programme of action research has been examining, over the last five years, this question from the personal perspective of women and men currently holding administrative posts in universities in North and Latin America and Asia. Data gathered from these parallel studies alerted us to the strong possibility that both power level and social context might be important factors in understanding how decision-making, within a strong academic ethos, differs between women and men.

In the attempt to address the methodological problems identified in earlier studies, a new paradigm was created in which both simple comparisons and multivariate analysis of variance could be made to account for the effect of G *gender* (sex/role attributes), P *positional power* (level of appointment, access to resources, value of the person's knowledge and expertise to the institution), E *environment* (institutional and cultural context) and S *system* (interaction among G x P x E). This analysis highlighted the importance of individual power level and institutional size as important variables that help to explain existing assumptions and stereotypes.

The study found the following factors affecting the number of women in senior leadership in Latin America universities.

The need to interact with peers – Women have less access to inter-institutional, inter-disciplinary networks, which undermines the ability of women to interact and consult with their peers.

Marginalization of talent – Institutional 'filters' screening potential leaders exist, based on preferred personal style, class status and sex.

Politics before merit – Women as well as men holding posts in public universities reported that political party affiliation too often took precedence over an individual's merits. This was seen most strongly in the responses of men, and less present in those of women. With fewer years in public service outside the institution and few opportunities to be sanctioned for office by constituency groups (students, faculty, political parties), women have a weaker lobbying group than men. The study found that women are more likely to be appointed where merit is the overriding selection criterion. Where women hold senior positions, they are more likely to be posts at the decanal level, where an academic reputation is strong and widely respected.

Posts of confidence – Many men do not believe that women possess the necessary attributes to carry out important responsibilities in a fully reliable fashion. Many men were willing to discuss these issues only in private.

Superwoman syndrome – Women leaders of today tend to impose themselves on others, and by example on other women, high standards and intense, singular commitment to professional practice, so that the expectation of being a superwoman may dissuade other, particularly younger, women from aspiring to leadership.

Women's complex lives – Women lead complex lives. For women leaders who are married, both family and work are considered the most important aspects of their lives. 'A woman expects she will do well at work and in raising her children. She feels guilty if she is not doing both'. Of those women who are married, the majority report spending between 20–39 hours per week on family activities, in addition to 40–60 hours per week on professional work. Women who continue to teach or work in their labs add 20 hours/week to their overall commitments.

Indicators and statistics on women's contributions to agricultural production[11]

The use and development of gender indicators in agriculture are determined by what are recognized as 'five general patterns of gender responsibility in agriculture'. They are:

- separate enterprises
- separate fields
- separate tasks
- shared tasks
- women-managed farms: de facto, in which men work away from the farm for days, weeks or years, while women manage in their absence; or de jure, legal women-headed households, which tend to be poor, with few resources and severe labour constraints.

Separate enterprises

Women and men are responsible for production and disposal of different crops and livestock within the household production system. For example, women may specialize in certain crops while also working with men in the production of others. Women may grow subsistence crops while men grow cash crops; or horticultural crops to men's cereal crops. Women may also specialize in poultry, small ruminants, gathering of wild crops, vegetables or tree crops, beans, cowpeas and other legumes.

Separate fields

Women produce the same crops as men but in different fields. Women's crops tend usually to be for home consumption and local markets, whereas men's may have a regional or national market. In West Africa, women's fields are usually part of a larger system in which the labour of both sexes is also contributed to the communal fields of extended households.

Separate tasks

Some or all of the tasks in a single cycle are assigned by gender. Commonly, men prepare the ground while women plant or transplant the crop. In many systems, women engage in seed selection and storage. Ploughing is done by men in most systems. Women's tasks also often include processing and storing of cereals, vegetables, tree crops dairy products, and care of animals when they are young and sick.

Shared tasks

Men and women share tasks on the same crop. In many systems, only labour-intensive tasks, such as weeding and harvesting, are shared. Shared tasks may signify greater flexibility in meeting labour demands for the activity. Will a new technology make a particular cultural practice a separate task and what would be the implications for the rest of the system?

Women-managed farms

De facto: Men work away from the farm while women manage in their absence. Men may work off-farm on a daily basis returning in the evening, or depart for weeks, months or even years. In many systems, women become the effective farm managers, sometimes with significant resources, but lack legal authority to sign credit agreements and commit resources.
De jure: This category is increasing rapidly. They tend to be the poorest farming households with few resources and severe labour constraints.

Other factors pertaining to gender responsibility in agriculture include:

- **the presence or absence of the husband in the household** can account for major difference in women's actions according to whether husbands are present or not. 'Intra-household relationships, not only whether one is the head of the household but the degree to which women receive payment from men in recognition of their work have a huge impact on what happens to the male related crop'.
- **class and stage in the life cycle** differentiate women from one another. In a study in Colombia on bean types, it was learned that young married women without children were engaged directly in agricultural production and were therefore market oriented, preferring beans for the urban market. Older married women with large families and responsibility for feeding hired labour and preferred a bean which swelled and was tasty.

11. From Feldstein et al. (1989), and Lilja and Sanders (1998). See also FAO, 1999.

Farming systems or whole-farm research

These questions and tools can be applied to the development of a set of indicators which look at a range of agricultural enterprises. The following model looks at farming systems not only in terms of costs and benefits but in relationship to other enterprises. The individuals who actually do the work, contribute resources and benefit from it are identified.

Activities analysis

An agricultural calendar shows the seasonal pattern of enterprises over the year. Inclusion of all production activities, not just major crops, will fully account for the pattern of and constraints upon labour. It should also include:

- Domestic production or home maintenance and women's reproductive roles.
- Gathering activities. Many important items for subsistence or sale are acquired by gathering in wild or public areas on a seasonal or ongoing basis.
- Non-farm production of goods and services through wage labour or other activities. In areas with landless households which engage in wage labour, this includes the identification of activities upon which they depend for income.
- Home processing of farm production or gathering which provides marketable goods for sale, such as baskets or beer.
- All activities should be disaggregated by sex.

Figure 5.8: Patterns of gender responsibility in agriculture

Pattern	Description	Research implications (indicators)
Separate crops	Women and men are responsible for production and disposal of different crops and livestock within the household production system.	Distinction between male and female-grown crops.
Separate fields	Women produce the same crops as men but in different fields.	On-farm trials should be carried out under both his and her conditions.
Separate tasks	Some or all of the tasks within a single cycle are assigned by gender.	Will proposed technological change increase or change time for male or female tasks with increased or decreased benefits?
Shared tasks	Men and women share tasks on the same crop.	Effect of technology on shared or separated nature of this task.
Women-managed farms		
a. de facto	Men work away from the farm for days, weeks or years, while women manage in their absence.	Status of household resources available to take advantage of technology adoption.
b. de jure	Women-headed households.	

Source: Feldstein, 1989.

Such a calendar will capture the seasonal patterns of gender responsibility for specific enterprises for tasks to improve understanding of the gender-disaggregated nature of agricultural tasks and to improve on the introduction of technologies or alternate crops.

Resources: Access and control

Assessment of resources or inputs for farm production will obviously need to take into account geographic and climatic factors. However, it is also important to understand which class and/or sex is responsible for the crop in question. Therefore resources for agricultural production need to be analysed in terms of access to and control of inputs, such as labour, land, water, cash, seed fertilizer and implements.

Control of a resource or input implies decision-making about its use. Access to a resource implies conditionality about using it and how it is used.

Access can be mixed. For example, men may control the amount and locations of fields allocated to women but women probably decide what is planted and how it is managed. Even if men use the technology and women make the financial decisions, as is the case in many parts of Asia, it will be crucial for technology adoption that the technology be evaluated in terms of the male and female criteria for effectiveness.

Benefits

In ensuring that agricultural research provides technologies that will be adopted by the farmers and will increase farmers' welfare, an analysis of uses and benefits of production will provide some indicators of acceptance by farmers. Three main questions apply:

- What are the products?
- What are the uses and desirable characteristics of these farm products, including uses of all parts of the plant or animal?
- Who has access to or control of the products and the income they produce? Will this pattern be an incentive for or hindrance to the allocation of any additional labour or resources required by a new technology?

Disaggregation of costs and benefits by sex helps anticipate which technologies will be accepted by whom. But farmer calculations also affect acceptance: Whose capital is invested and who keeps the capital earned? Whose animal power is used and who keeps the crop produced? Factors other than yields and returns frequently affect farmers' acceptance of proposed changes. This is particularly true in peasant households with limited resources. Ability to quickly identify these factors by sex can help enhance understanding the whole farm system and provide criteria against which to evaluate further research.

Case study: Welfare impacts of technological change on women in Southern Mali (Lilja and Sanders, 1998)

In this study, Lilja and Sanders (1998) estimate the income gains and losses from the introduction of new technologies into communities in Mali in 1994/95. In Mali most resources and revenues of the farm household are managed by the male head of the household. Household members work on the 'communal' or household lands, and when sufficient land is available, are allocated private plots for income and additional food consumption. These private plots are generally a secondary activity of the household, but very important to women. Private plots can only be worked after other household and communal production obligations are fulfilled.

The purpose of this study was to estimate the income gains and losses from reallocation of women's labour from private production to communal production. This was done by:

1. comparing income gains of the men and women who own private plots from their increased labour contribution to communal production; and
2. comparing income losses due to reduced private-plot labour allocations with the increased wage payments for communal labour.

Overall, the study found that even though women are paid higher wages for additional labour on communal fields required by technological change, the consequent decline in their private-field labour input results in reduced total remuneration in almost all cases studied.

In assessing income change, the study discovered that women's communal wages were determined by the area of land cultivated, the woman's ability to bargain (related to standing in household), and the opportunity cost of the woman's time. It found that:

- expanding cotton production in Southern Mali increased benefits to each woman by a very small amount
- where the increase in communal labour participation equaled the reduced amount of participation in private plots, women in all four regions studied experienced decreased income
- where half of the increased communal labour allocation was found in private-plot labour reduction and the other half in decreased leisure or increased efficiency, in other activities women still experienced reduced income
- only in two villages where technology introduction had taken place earlier could a one-fourth reduction of private-plot labour provide an increase in income which could possibly derive from a gradual evolution of higher wages to women over time after the introduction of new technologies.

The policy implications and recommendations of this study included:

- recommendation that women's welfare can be improved by increased access to land and inputs
- recognition that returns to women's labour are higher in private than communal production, and that there is therefore significant potential for increasing private-plot returns by increasing inputs
- investment in rural infrastructure could promote market-led intensification and increase producer incentives for crops traditionally grown by women.

Important factors in assessing outcomes (and potential indicators) include:

- men's tendency to shift into private-plots when they become more profitable
- women's ownership of or rights to use land
- women's degree of bargaining power within the household
- comparisons of men's and women's spending habits (men spend a greater proportion of their income on luxury goods while women are more likely to purchase food and medicine).

Suggestions for further research are to:

- evaluate the impacts of technological change on the head of household's expenditures, and their relation to the welfare of women and children
- analyse the nutritional effects of change in labour allocation from private to communal fields.

Gender-sensitive indicators (GSI) in the management of natural resources,[12] Food and Agriculture Organization (FAO)

GSI are developed through the identification of gender sensitive factors that put differential pressure on the management and use of natural resources. GSI indicators can be used to monitor the impact of a specific project, but can also be expanded to include monitoring of whether and how the relationship between women and men and their natural resources evolves and changes over time. Thus the systematic monitoring of GSI will allow the formulation of more sustainable, efficient and effective development responses.

Indicator 1: Women's and men's descriptors

Baseline: The quantity and quality of descriptors used for a given natural resource by women and men in period 0 (baseline).

GSI data required:

- The type and number of descriptors used for a given natural resource by women, compared to the baseline.
- The type and number of descriptors used for a given natural resource by men, compared to the baseline.

GSI:

- The ratio between the number of descriptors used by women versus men for a given natural resource, compared to the baseline.

The descriptors or preferred traits of local agrobiodiversity of women and men farmers provide information about Natural Resources Management (NRM). Descriptors are dynamic and may change according to terms of trade and cultural or overall variations in opportunities and constraints as perceived by the farmer. The ratio referred to in the indicator allows for the monitoring of the gender gap. In the context of descriptors, let us say that women provide

12. From FAO, 2003.

15 descriptors for a given variety, and men provide 3 at the baseline. The ratio is thus 15/3. Let us say that after two years, women's descriptors have decreased to 10 and men's have increased to 5 (ratio 10/5). This would show that the gender gap has diminished. This information may indicate that men's knowledge and management responsibilities of the given variety have increased relative to women's.

Indicator 2: Women's and men's access to agricultural inputs

Access to resources is intimately linked to different spheres of responsibility. Rural women and men have several resources at their disposal and differential access to those.

Income. Women's wages are often less than men's because their work is considered casual, easily exploitable and non-essential to family income.

Seeds. In parts of India, for example, it is considered improper for a woman to buy seeds with money. They are not allowed to deal with 'impure' high-yielding varieties bought at the market that men sow and look after.

Water. Until recently in Egypt, irrigation was regarded as a man's job because it was mechanized and often occurred at night. As in other countries, Mansour (1994) confirmed that in Egypt, women, and never men, collect and transport water for household use, and dispose of household wastewater either by carrying it to the ditch or throwing it out near the house.

Credit. With limited income, access to credit may be the only means to access inputs. 'Credit' is a broad term and may include savings groups with neighbours or members of an interest group and larger micro-crediting schemes at the village level and commercial credit available through the formal system. Often women have an insufficient amount of land to mortgage in order to secure bank loans.

Labour. One of the key inputs required to prepare the reclaimed lands in Egypt. To meet the labour demands. It has been observed that children, teenage girls and women are bussed daily from the village to work as contractual seasonal labourers at the expense of their own education (ARE, 1999).

Land. In Nepal, it was found that well-endowed households conserved agricultural biodiversity better than poorer households due to the formers' access to land. Exclusive male responsibilities included ploughing, application of chemical modern technologies, planting by broadcasting and irrigation.

Baseline: The amount and type of agricultural inputs used by women and men in period 0 (baseline).

GSI data required:

- The amount and type of agricultural inputs used by women.
- The amount and type of agricultural inputs used by men.

GSI:

- The ratio between the amount and type of agricultural inputs that women versus men use, compared to the baseline.

Indicator 3: Women's and men's access to land

Does ownership of a natural resource affect the willingness to manage it sustainably? There are those who argue that insecure property rights lead to less willingness to make long-term improvements to land, hence accelerating natural resource degradation (UNCCD, 1999). However, women also sustainably manage land that they do not own, either because their tenure is threatened or as a symbolic gesture to their husbands and community that they are 'good' wives and farmers (Verma, 2001).

In most parts of the world, sex and socio-economic status are key determinants for access to and control over land. In Nepal, land is distributed through the male branch, and only unmarried women aged 35 and over are allowed to inherit from their parents a share of land equal to their brothers'. It is often noted that when women have access to land, they are given the most fragile areas and resources. When competition for land increases, often their access to land is at risk. Land degradation (deforestation and desertification) is harder on women since they have to spend more time in finding fuelwood, fodder and water.

Baseline: The quality and quantity of land accessed by women versus men in period 0 (baseline).

GSI data required:

- The quality and quantity of land accessed by women.
- The quality and quantity of land accessed by men.

GSI:

- The ratio in volume of land as accessed by women versus men, compared to the baseline.

- The ratio of quality land as accessed by women versus men, compared to the baseline.

Surveys of land holdings, sizes and number of parcels of women/men will enable monitoring of the ratio in volume of land as accessed by women versus men. It may be necessary to complement this by interviewing land managers in order to understand the dynamics of land access. Particular attention must be paid to households that are de facto headed by women.

Soil fertility surveys and qualitative interviews with women and men farmers will enable monitoring of the ratio of quality land accessed by women versus men. This will allow us to understand the way in which the gender gap in access to quality land evolves over time.

Indicator 4: Women's and men's time dedicated to the sustainable management of natural resources

New technologies may be introduced that allow for more effective, less time-consuming management. However, the introduction of new technologies often affects the division of labour between women and men. It has been noted that when a female sphere of responsibility is mechanized, it will often be included in men's responsibilities (Radoeva, 2000). The way in which new technologies will influence the sustainable management of resources will depend on the alternative use of the liberated time.

Baseline: The number of working hours put into the management of a given natural resource by women and men in period 0 (baseline).

GSI data required:

- The number of working hours women put into the management of a given natural resource.
- The number of working hours men put into the management of a given natural resource.

GSI:

- The ratio between the number of working hours women versus men put into the management of a given natural resource, compared to the baseline.
- Time use surveys can also be helpful tools. The latest *Human Development Report* (2002) provided comparable data on the work burden of women and men, and their allocation of time for market versus non-market activities in rural areas in selected countries, based on time-use surveys.

Indicator 5: Women's and men's (indigenous) knowledge associated with the management of natural resources

Women and men, young and old, often have different knowledge systems. In Botswana, for example, it was found that men's knowledge about the conservation of traditional leafy vegetables was general, while women's knowledge was more detailed and specific (Matlhare, 1999).

There is a widely documented gender gap in participation of farmers in agricultural training. Thus, it is no surprise that the training offered to women has been in income-generation activities and skills that relate to their domestic activities. In addition, there is limited availability of female specializts. According to El Sanabary et al. (1999), extension agents do not fully understand women's actual roles in agriculture, and female extension agents face constraints related to limited mobility, lack of transportation, and conflicts of availability of women extension workers (mornings) and women farmers (afternoons).

Baseline: Women's and men's indigenous knowledge associated with the management of traditional varieties in period 0 (baseline).

GSI data required:

- Establish women's (indigenous) knowledge associated with the management of traditional varieties.
- Establish men's (indigenous) knowledge associated with the management of traditional varieties, compared to the baseline.

GSI:

The ratio between women's versus men's formal knowledge associated with the management of natural resources, compared to the baseline.

- The ratio between women's versus men's indigenous knowledge associated with the management of natural resources, compared to the baseline.
- The levels of formal education of women and men is an important indicator that can allow monitoring of the ratio between women's versus men's formal knowledge associated with the management of natural resources.

Due to a low level of formal documentation, it is difficult to monitor the ratio between women's versus men's indigenous knowledge associated with the management of natural resources. However, many organizations are currently investing energy in documenting indigenous knowledge, which could be an important entry point for monitoring indigenous practices.

Indicator 6: Women's and men's participation in development response strategies

Women and men participate differently in formal and informal community-based organizations, and use different networks for the management and use of natural resources.

Baseline: The number and level of participation of women and men in response strategies in period 0 (baseline).

GSI data required:
- The number and level of participation of women in response strategies.
- The number and level of participation of men in response strategies.

GSI indicators:
- The ratio between the number of women versus men participating in response strategies, compared to the baseline.
- The ratio of the level of women's versus men's participation in response strategies, compared to the baseline.

Associated indicators used to understand the participation of women and men and socio-economic groups include:

- Number of women and men attending identification and planning meetings.
- Degree of women's and men's inputs into project activities in terms of labour, tools and/or money.
- Benefits going to women and men, by socio-economic background and age.
- Level of participation as perceived by women and men through the different stages of the project cycle by sex, age and socio-economic background.

Collecting data on women's participation in the informal sector[13]

Women's activities in the informal sector have long made important but invisible contributions to national economies. Estimates of the contribution of women to employment and GDP are indispensable for economic policy decisions and planning. It is estimated that women's informal-sector activities in Africa constitute one-third of GDP and worldwide amounts to $11 trillion annually. The programme on Women in Informal Employment: Globalizing and Organizing (WIEGO) organized by UNIFEM, the Self-Employed Women's Organization (SEWA) and the Harvard Institute for International Development is developing methods to collect data on women's participation in the informal sector. In this section we look at data collection for women's activities in the informal sector, as homeworkers and as street vendors.

Defined by the Fifteenth International Conference of Labour Statisticians in 1993 as a new concept of labour force, the informal sector comprizes units in the household sector, as defined by the System of National Accounts (ISWGNA 1994), and which therefore are unincorporated enterprises or do not hold a complete set of accounts, including:

> i) units – registered or not – without permanent employees,
> ii) units with permanent employees and which are, alternatively or simultaneously: unregistered units, or do not register their permanent employees, or employ, on a continuous basis, less than a given number of persons, according to the legislative codes (fiscal or social) or to the practices of survey statisticians when they design the scope and coverage of enterprises surveys.

Broadly defined, the international concept distinguishes between two sub-categories of informal-sector units:

- family enterprises' comprized of independent or own-account owners, family workers, apprentices and casual workers, and with no permanent employees
- micro-enterprises' comprized of units with less than five to ten employees (or jobs), or which do not register them, or which are not registered as enterprises.

13. From Charmes, 1998; and Ferran, 1998a and b.

Activities in the informal sector which are particularly difficult to capture in statistical surveys include:

- home-based workers, be they outworkers (or piece-rate workers) or own-account workers, and more generally, all activities undertaken in domestic premises
- itinerant or seasonal or temporary jobs on building sites or road works
- second jobs or pluri-activity
- street vendors.

Informal sector

Case study: Concepts and techniques for estimating the contribution of women in the informal sector (Ferran, 1998b)

The main sources for the labour component of women working in the informal sector are employment statistics classified according to the *International Classification of Status in Employment* (ICSE) and by gender. The ICSE identifies persons working in informal household enterprises, but those working in enterprises of informal employers are not recorded separately.

Definition

The Fifteenth International Conference of Labour Statisticians defines the informal sector as 'a group of production units which, according to the definitions and classifications provided in the United Nations System of National Accounts (Rev. 4), form part of the household sector as household enterprises or, unincorporated enterprises owned by households' (ILO, 1993, Para. 6).

The relevant part of this definition for the collection of data on informal-sector activities is the identification of the informal production units as household enterprises, also called unincorporated enterprises owned by households. For data collection this presents a problem. Most women do not conceive of their work as taking place in an 'enterprise', which in their reasoning is something big and important, quite different from what they are doing. It will be up to the survey-taker to dispel such doubts.

Two features distinguish household enterprises from other enterprises:

a) the legal organization and
b) the keeping of accounts.

Legal status distinguishes them from corporations and the existence of bookkeeping from quasi-corporations. The existence of adequate accounting records distinguishes, on one hand, the household enterprise from a quasi-corporation and, on the other, allows the separation of financial transactions of the household enterprise from those of the household as a consumer. However, such pre-existing records usually are not available in the case of informal sector units, and the information must be obtained by questioning.

It is noteworthy that the Urban Informal Sector Survey of the Philippines poses questions regarding the accounting records of the productive unit, and specifically if it keeps records on orders, sales, purchases and cash flows.

Household enterprises can be of two different kinds:

a) informal own-account enterprises and
b) enterprises of informal employers.

Informal own-account enterprises are those owned and operated by own-account workers; they may employ contributing family workers and/or employees on an occasional basis.

Enterprises of informal employers are those that employ one or more employees on a continuous basis, generally between four and ten employees. According to national studies, informal own-account enterprises represent by far the major part of all household enterprises.

Household enterprises are defined irrespective of the extent of fixed capital assets used, the location where the work is carried out, or whether the operation of the enterprise is perennial, seasonal or casual.

Household enterprises engaged in 'the production of goods and services for own final consumption or own fixed capital formation as defined by the United Nations System of National Accounts (Rev. 4) should be excluded from the scope of the informal sector for the purpose of statistics of employment in the informal sector' (ILO, 1993, Para. 14). In the case of women working for the market and keep some of the products for their own use, or their families', the amount used for own consumption should be included in the output of their enterprises (ISWGNA, 1994, Para. 4.146).

Collection of data

The Resolution makes the following recommendations on data collection programmes and methods: the collection of data on the informal sector should be integrated into the regular national statistical system and should contemplate current monitoring (once a year) and in-depth inquiries (every five years), covering not only employment (numbers and characteristics of those employed), but also data on production and income. Concerning procedures for estimating the contribution of women working in the informal sector, what is needed is a cross-classification of data on production and income by sex.

Data collection should be based on household surveys, using households as reporting units and household members as observation units, while for in-depth studies, establishment surveys or mixed household and enterprise surveys are preferred. In these latter cases it is the informal-sector unit that is used for observation and reporting.

Finally, the Resolution states that 'other measurement methods can also be considered, such as methods of indirect macroeconomic estimation or the comparative analysis of data from different sources'.

What is needed is information on the value of output and on intermediate consumption, and, in the case of informal employers, also on compensation of employees. Output and intermediate consumption relate directly to the production unit, and hence to the own-account worker or to the employer whose sex should appear in the questionnaire. The amount paid to employees appears usually without a distinction by sex, making it impossible to specify the amount paid to women. This must be taken into account in questionnaire design.

A question arises with respect to unpaid family workers. They do not receive pay but contribute to the output of the enterprise. If the worker and the owner of the enterprise are both women, the mixed income generated by the enterprise reflects correctly the contribution of women. But if not, the contribution of female workers in a male-headed enterprise must be calculated separately and added to the contribution of women. In the case of male workers in an enterprise headed by a woman, their contribution must be deducted from the mixed income of the enterprise. As no payments are taking place, the contribution can be estimated only approximately using time worked and wages paid in the market.

Two different techniques for estimating the contribution of women working in the informal sector are presented. The Venezuela example has been based on sources available in the Statistical Office of Venezuela (OCEI). The second technique was developed by the South American Multidisciplinary Technical Team of the ILDO to estimate the contribution to GDP by the informal sector as a whole (Castiglia et al., 1995). It is extended to the part contributed by women, based on data sources from Costa Rica.

Case study: Venezuela

Inventory of available data

There are several potential sources for estimating the economic contribution of women working in the informal sector: i) the Population and Housing Census, ii) the Sample Household Survey, iii) the Family Budget Survey, iv) specific ad hoc surveys related to the informal sector, v) administrative records, and vi) the national estimation of wages and salaries paid by type of activity.

The Population and Housing Census of 1990 is a census *de jure*. The variables registered in the census were distributed between two types of questionnaires: a basic one addressed to the whole population and an amplified questionnaire covering a specific sample of the population. The basic questionnaire contained a question on the situation within the labour force for all persons over age 12, and the amplified questionnaire, in addition to the above, recorded occupation, type of economic activity, size of the enterprise in which the person worked, status in employment, income from work, and other sources of income. It also includes a question concerning the informal sector. The informal sector is defined as 'That part of economic activity… which comprizes persons employed as domestic service, non-professional own-account workers, as well as the employers, employees, workers and family workers who work in enterprises of less than five persons'.

The sample household survey has been carried out twice a year since 1967. It covers the entire population with the exception of the population living in collective households. The sampling frame is the Register of Structures and the cartography of the Population and Housing Census. Census data on population by sex and age group are extrapolated to the central point of each semester. The

survey uses probability sampling in three stages. The questions on economic status are prevalent, because its main aim is to measure employment and its characteristics, one of which is the income of workers. It produces data at national level and shows classifications by sex.

The family budget survey is much less frequent, with national level data available for 1988 and 1997. This survey includes questions on economic status as well as on income and family expenditures.

The specific surveys related to the informal sector are small, circumscribed to certain localities and are branch specific.

Administrative records include social security data, information from the income tax and municipal records.

The national estimate of wages and salaries paid by kind of activity is prepared yearly by the Central Bank of Venezuela.

Use and adjustment of the various sources

The Population and Housing Census is indispensable as the framework for sample surveys. For the domain of study under consideration, there are only a few questions on economic matters and these are usually under-reported. The census is carried out every ten years, and there is a considerable delay in publishing results.

The Sample Household Survey, available for a long series of years, includes several questions on economic status, characteristic of employment, size of income from work, as well as questions on demographic and social characteristics. The results are available very soon after the end of the semester and provide full information on the changes in employment conditions. It is an excellent source for the present purpose. However, it does not furnish information on the value of output and intermediate consumption of the informal units, so that for the estimate of the contribution of women in the informal sector, one has to work with the data on income contained in the survey. While for some users such data are satisfactory, for the given purpose, response errors tend to be high. Hence it was decided to use the Sample Household Survey as the main source for the estimate, but to adjust the survey figures on income by information from other sources.

Such an additional source is the Family Budget Survey. It has more or less the same questions on economic activity and characteristics of employment, as well as on income of the informal units. However, the information obtained through this survey is considered more reliable because interviewers and supervisors dedicate more time to the interviews and the correction of non-sampling errors. In addition, it allows comparison of the data on income with those on expenditures.

Specific surveys on the informal sector carried out in Venezuela are limited in their coverage of space and activities. They mainly aim to determine the number and certain social characteristics of street vendors, who perform their activity in specified places.

Social security and income tax records were discarded as a source of information because neither covered the universe of the present domain of study. However, in certain cases information from municipal records was used to check data from the Sample Household Survey.

As part of the national accounts, the Central Bank of Venezuela publishes each year a table on wages and salaries by industrial origin. This information is used in the estimate of women's contribution to adjust the figures obtained from household surveys.

Collating definitions and procedures

The definition of the informal sector used by the Statistical Office of Venezuela (OCEI) includes workers in urban and rural areas and distinguishes between the following categories (the percentages indicate the distribution of women employed by category):

- domestic servants living in employer's household (those who live in their own home are considered own account workers) (14.3 per cent)
- own account workers (64.2 per cent)
- employers in enterprises with less than five workers (2.8 per cent)
- employees in enterprises with less than five workers (15.9 per cent)
- unpaid family workers (2.8 per cent).

As the number and sex of these workers classified by categories indicated above, are given in the Sample Household Survey, the estimation procedure can calculate value added by women in the informal sector.

Calculation of value added

Because neither the value of output nor the intermediate consumption of the informal unit is known, the estimate of value added needs to be built on information regarding

income. Specifically, the net income declared in the Sample Household Survey by female own-account workers and female employers plus the income of their female employees is considered equal to the value added of the corresponding enterprises. The contribution of unpaid family workers is part of the income of the unit in which they work.

Adjustment of declared income

Due to the extended under-reporting usually observed in declarations of income, the figures thus obtained are adjusted. The adjustment is necessary to bring the figures of the informal sector in line with the national accounts aggregates. The adjustment is made using the national accounts estimate of wages and salaries by kind of economic activity. For this, the informal sector figures are classified by kind of economic activity and for each separate item the Statistical Office prepares a coefficient of underestimation. These coefficients are then applied to the data of income of workers by sex and kind of economic activity obtained from the Household Survey. This adjustment increases the percentage of the informal sector within total income from work (remuneration of employees and mixed income) from 29.4 per cent to 33.6 per cent.

The female participation in the informal labour force is 34 per cent, while their share in the income generated in the total informal sector is 23 per cent. This difference reflects the inequality in income earned by women. This may be due to the fact that women undertake the lowest paid services and petty trade. It must be remembered that usually the income perceived by these women means not only their own survival but that of the population dependent on them; most live in poverty, and the rate of dependency in this group is higher than the average. The breakdown by activities is given in the table 5.1.

Table 5.1: Participation of women in income generated by informal sector, 1997

All informal sector	23%
Agriculture	2%
Non-agriculture	26%
Oil and mining	9%
Manufacture	26%
Energy	15%
Construction	1%
Trade	33%
Transport and communication	3%
Financial enterprises, real estate insurance and services to enterprises	24%
Communal, personal and social services	36%

Weaknesses of the procedure

The procedure described has several weaknesses. One is that it does not use values of outputs and inputs, which usually provide a better approximation to the real value of the contribution to GDP. Another shortcoming is its failure to take account of the possibility that male unpaid family members may be working in female-headed productive units and vice versa. However, the percentage of persons in that category is relatively small and these two situations may compensate each other.

In Costa Rica (a similar procedure was also applied for Panama) the estimate refers exclusively to the urban informal sector without distinction of sex. The technique used in the Venezuela example assumed that income created in the sector is equivalent to its product. This technique uses the distribution of the economically active non-agricultural population between the informal and the modern (formal) sectors, the percentage of unemployed, the ratio between average income in the informal sector and average salary in the modern sector. With these variables this procedure approximates the participation of the urban informal sector in the non-agricultural GDP. Then it refines the result by adding depreciation, indirect taxes paid by the sector, as well as subsidies received by producers and their families. This increases the participation of the informal sector from 11 per cent to almost 14 per cent. A more detailed description of the method is given in Castiglia et al. (1995).

The next step for the present purpose is to derive from the total contribution of the informal sector that part which is due to the work of women. Given the framework of the procedure just mentioned, two main calculations are needed:

a) the fraction of women workers within total employment in the urban informal sector
b) the ratio between women's and men's average income in the informal sector.

This information can be extracted from most Household Sample Surveys. Special inquiries are now available which are designed specifically for the collection of information on the informal sector. Modules concerning the informal

sector have been attached to household surveys, or specific questions included in economic censuses or a combined two-stage household–enterprise survey. These new inquiries produce substantially improved data on the economic activities of women in the informal sector.

Since 1991 Peru has had an Inter-institutional Statistical Commission for the Informal Sector (CIESI), including public and private institutions, to propose policies for the elaboration and distribution of statistics on the informal sector. The 1993 Population and Housing Census contained questions on informal activities of persons and in the section on housing, questions on whether part of the living quarters were used for economic activities producing income. The Third National Economic Census created directories of productive units subdivided by geographical areas, the amount of gross value of production, and number of employees. Finally, the National Multipurpose Inquiry included a special module on establishments of one to ten workers, which inquired about the basic characteristics of the enterprise, volume of production, value of output and costs of inputs, credit and savings, and labour force. The survey produces data on the distribution of the informal enterprises by kind of activity, asks questions on licenses and permits, accounting records, location of their activities, and asks detailed questions on the characteristics of the personnel working in the establishment. Questions on sex appear exclusively in the last part of the questionnaire, which is concerned with the labour force. For each employed person, including the proprietor, the questionnaire inquires about sex, occupation, age, educational level, status in employment, hours worked during last week, type of remuneration and amount earned.

The figures for Peru confirm the concentration of women in certain activities, although in the informal sector as a whole the proportion of men employed is higher (58 per cent). In food related activities, 76 per cent are women, in trade 53 per cent are women and in other services women represent 52 per cent (Chávez, 1998).

Various sources and techniques are used in Colombia for the measurement of the informal sector in terms of its role in employment and its significance for production and income.

The procedures are based on direct inquiries: the Multi-sector Economic Census at the national level, a special 'informality module' included every two years in the National Household Survey, and an ILO-sponsored in-depth 'Mixed Survey of the Informal Sector'. The Economic Census measures the aggregate value of informal activities and its relative weight in national production. The informality module includes questions on size, time worked, location (at home, other living quarters, cubicle or kiosk, vehicle, door-to-door, outdoors, fixed location), and access to social security. The informal sector is subclassified by degree of informality, type of personnel employed, kind of proprietorship, and size of the enterprise measured by the number of persons employed (up to ten in manufacturing and construction and not more than five in other activities). The operational definition of informal employment comprizes self-employed workers, (excluding independent professionals and technicians), paid workers and employers in companies with less than ten workers, and domestic service with or without pay.

For Colombia, the informality module produced the following figures: for 1996, informal employment was more than half (53 per cent) of total employment in ten main cities and metropolitan areas. In 1984, it was somewhat higher, 58 per cent (Galindo, 1998).

Home-based work

Case study: Concepts and classifications to improve statistics on home-based workers (Ferran, 1998a)

In the wake of increased flexibility of the labour market, there has been an increase of dependent and independent home-based workers. This has led the ILO to adopt the 1996 Home Work Convention, which covers specifically the dependent home-based workers, called homeworkers. The Convention calls for improving statistics on homeworkers.

This has significant implications for statistical definitions and concepts. Statistics concerning this kind of employment are very scarce, and no broad consensus exists concerning its suitable definition and its place in the classification structure, as homeworkers exhibit simultaneously the characteristics of paid employees and the self-employed. Here we take up those issues relating to relevant definitions and classifications.

Homeworkers (dependent) are workers with the following characteristics:

- they work at home, outside the establishment that buys their products, either goods or services

- they agree by prior arrangement to supply goods or services to a particular enterprise
- their remuneration consists of the prices paid for their products
- they do not employ workers on a regular basis.

They may or may not contribute tools, equipment and other material inputs. These workers should be classified in a separate group called 'homeworkers', which differ from 'employees' and 'own-account workers'.

Independent home-based workers are those who work at their home and deliver their products or services to any prospective buyer. Their characteristics are those of the self-employed and they should be classified as part of the group 'own-account workers'.

The current situation in the labour market is characterized by many employment situations that are intermediate to the classical dichotomy of 'paid employment' and 'self-employment'. According to a recent publication, workers 'fall along a continuum of possible labour relationships from full-time employees to casual employees, to dependent workers to semi-dependent workers, to self-employed or fully independent workers'. Specifically 'homeworkers... represent a fundamental challenge to the inherent dualism of labour law'. This also challenges the application of the classification of the *International Classification of Status in Employment* (ICSE).

Though it is difficult to follow the development of this specific category of workers, some figures are available on home-based workers which shed light on their importance: in Botswana 77 per cent of enterprises are located in households, in Kenya 32 per cent, in Lesotho 62 per cent, in Malawi 54 per cent, in South Africa 71 per cent, in Swaziland 68 per cent, in Zimbabwe 77 per cent.

In order to find a classification to effectively guide the decision of statisticians, we must examine criteria and concepts. The following definitional criteria underlie the classification of employment:

- location
- contribution to the cost of production
- ownership of means of production
- risk
- kind of supervision
- existence of a contract or arrangement
- degree of autonomy and economic independence
- remuneration
- sale of work or goods and services
- payroll.

Location

This refers to the place, rural or urban, where the work is carried out. All those who work outside the establishment to which they sell their products are called 'home-based workers'. Some possess a certain degree of autonomy and economic independence and are referred to as 'independent home-based workers', others do not have that degree of autonomy and are called 'dependent home-based workers', or simply 'homeworkers'. This is the category exclusively covered by the Convention. Occasionally salaried employees may perform some work as employees at home, but they are not considered homeworkers (ILO, 1996, Art. 1b).

Contribution to the cost of production

There exists a substantial difference in this respect between homeworkers and salaried employees. The fact that the work is being done by a homeworker, at the homeworker's premises, means that not only the rent but also cleaning, heating, electricity and similar expenses are paid by the homeworker. Enterprises with salaried workers have to pay such expenses themselves. That can represent a substantial difference in costs, especially in labour-intensive industries. And it explains the extended use of homework in such industries.

Ownership of means of production

Salaried persons use means of production of the owner of the enterprise in which they work. They contribute to the process of production only in the form of their work. Homeworkers contribute not only their work, but also capital in the form of the place of work, and sometimes also tools, machines and material input. The amount of capital does not matter; in fact, it may be minute.

Risk

Risk is another criterion that distinguishes the salaried employee from the homeworker. The category includes the risk of the entrepreneur (financial miscalculations) and the worker's risks due to the precariousness of employment and to accidents in the process of production (e.g. fire). Salaried employees generally do not incur losses of property in the process of production. Health hazards in the case of those who work at their homes may affect the

whole family. Surveys show that work irregularity and health hazards are the risks most frequently mentioned in the complaints of homeworkers.

Kind of supervision

The provider of work does not have any direct supervision in the production carried out by the homeworker. He or she may, however, refuse to accept the product if he or she considers that it does not conform to the specifications given.

Existence of a contract or arrangement

A contract can be in writing or purely verbal and an arrangement can be more or less binding. In extreme case – and this seems to be the prevailing situation in the case of homeworkers – the arrangement can be repealed at any moment.

Degree of autonomy and economic independence

The degree of autonomy and economic independence is determined by the economic relations of the workers: whether they deal with a single person or establishment with whom they have some kind of arrangement, or act independently in the market. In the first case, the worker is classified as a homeworker; in the second case, as an independent home-based worker or own-account worker. Doubts may arise when a worker, who habitually sells to one purchaser, turns to the market for selling some goods or services in the market. The decision should be based on which of the two outlets is more important in terms of the value of sales.

Remuneration for work

This relates usually to the time element (although sometimes also to pieces produced), while prices reflect the value of goods and services. The latter holds of the homeworker, so that what s/he receives is a price per unit of product s/he sells. In terms of the national accounts, what is paid to an employee is called 'compensation of employees', while the income of a person producing goods or services combining his/her own work with some capital is called 'mixed income'.

Sale of work or of goods and services

This is a fundamental criterion, as it determines not only what kind of remuneration is received but also the position within the classification structure and the national accounts. The question is whether what is sold is work in itself or the result of work, namely goods and services. On this the Convention is adamant: it is the result of work in the form of goods and services that counts. Homeworkers sell the results of their work. Sale of work refers to the contribution of only one factor, namely labour, while in the case of sales of goods or of services both labour and capital are involved.

Payroll

Salaried workers and employees are on the payroll of the employing organization. Additional costs, such as payment of relevant taxes and social security contributions, can be avoided by using homeworkers, who do not appear on the payroll, because the corresponding transactions are recorded as purchases of goods or services.

National accounts

The concepts expressed above refer to employment. The economic aspects appear in the national accounts. The *1993 System of National Accounts* (ISWGNA, 1994) employs the concept of 'outworker', who can be an employee or a self-employed worker. Paragraph 7.27 reads:

> Outworkers have some of the characteristics of employees and some of the characteristics of self-employed workers. The way in which they are to be classified is determined primarily by the basis on which they are remunerated: (a) The person is remunerated directly, or indirectly, on the basis of the amount of work done,... irrespective of the value of the output produced or the profitability of the production process. This kind of remuneration implies that the worker is an employee; or (b) the income received by the person is a function of the value of the outputs from some process of production for which that person is responsible, however much or little work was put in. This kind of remuneration implies that the worker is self-employed.

Moreover, Paragraph 7.26 reminds us that 'outworkers meet some production costs themselves: for example, the actual or imputed rent on the buildings in which they work; heating, lighting and power; storage or transportation; etc'. Paragraph 7.30 also draws attention to the fact that:

> When the outworker is an own-account worker, the payment from the enterprise to the outworker constitutes a purchase of intermediate goods or services. When

the outworker is an employee, the payment constitutes compensation of employees and is therefore paid out of the value added of the enterprise. Thus, the autoworker's status affects the distribution of value added between enterprises as well as the distribution of incomes between compensation of employees and net mixed income.

Street vendors

Case study: Street vendors in Africa – New data and concepts (Charmes, 1998b)

The recent and rapid expansion of this segment of the informal-sector labour force which operates outside an enterprise's premises has enlarged the concept of street vendors in many countries to the category of streetworkers, which includes: tailors specialized in mending who carry their sewing machines on their heads, hairdressers who carry their stools, cheap and fast meal sellers and cycle and motor vehicle repairers. Such workers for a long time have taken to the pavements and the streets of the towns.

Outworkers and street vendors are probably the most important and the most challenging to evaluate for a better understanding of the informal sector. Here we present data on street vendors in several African countries and discuss the concept or definition used to identify street vendors and methods of enumeration.

Selected data on street vendors: Share in employment and levels of incomes

The importance of street vendors in informal employment, and especially in female employment, is attested by specific and comprehensive data collection operations in various countries, particularly in Africa, where this type of activity is widespread.

Street vendors represented around 30 per cent of informal employment in Niamey, Niger, in 1982 (Charmes, 1982) and 38 per cent (or 31.2 per cent of total employment) in the five main towns of Guinea in 1987 (DGSI/PAGEN, 1987). In Guinea, commercial activities accounted for more than 80.6 per cent of total employment in street vending and street vendors for more than 63.5 per cent of total commercial employment. Unfortunately, it is not possible to disaggregate these data by sex.

Sex-disaggregated data were collected and tabulated in the 1992 surveys in Benin (Maldonado, 1994; Charmes, 1996). Using the same methods of estimation as in Guinea and Niger, street vendors in Benin represented 80.7 per cent of all economic units enumerated in urban areas (the ten major cities), and women accounted for 75.2 per cent of the street vendors. These figures corresponded to 68.5 per cent of urban informal employment and 63.5 per cent of total urban employment (outworkers were not taken into account). Women's share rose to 61.5 per cent of total labour force engaged in the informal sector, and to 52.8 per cent of the urban informal labour force. Street vendors accounted for 33.7 per cent of total urban informal labour force, of which 76.7 per cent were women. As a whole, female street vendors represented about a quarter (25.9 per cent) of the total urban labour force engaged in the informal sector, and 23.7 per cent of the total urban labour force (modern sector and outworkers included).

Figures on levels of incomes earned by street vendors are more scarce, but where they have been collected, they have proved to be higher than the usual assumptions and theories. Usually considered as subsistence or survival activities, street trade provides incomes several times higher than the legal minimum wage (4.2 times in Niamey, 1982).

In Latin America (PREALC, 1988) and in Asia, studies undertaken on street vendors referred to the working poor and activities for survival, and remained qualitative. In Africa, these activities have been tentatively approached on a statistical basis.

Methods for measuring the street vendors

Content and characterization of the concept

When dealing with the question of the enumeration of street vendors, the place of work is the first and main criterion used to characterise this category. The Mali 1985 Demographic Survey distinguished the following ten types of location (this classification has been used in all subsequent labour-force or informal-sector surveys):

- enterprise
- shop or workshop
- building sites or road works
- fixed market
- mobile market
- home with specific outfits

- home without specific outfits
- street
- mobile
- other.

It would be useful to add collective courtyard to this list. Other countries (for example, Guinea in 1987 and Niger in 1982) have further specified street vendors in fixed locations by distinguishing:

- street vendors with only bowls, baskets or mats
- street vendors with stools
- street vendors with tables (called table-owners or dressers in Niger)
- street vendors with porch-roofs or sheds, or window dress.

The categories for mobile street vendors (hawkers and peddlers) were:

- walking street vendors
- street vendors with cart, bicycle, etc.

More recently such manufacturing activities as furniture makers or metal workers are leaving the courtyards to work on the street. The share of street vendors in the crowd of street workers has tended to drop. To take account of these changes, two items should be added to the classification of location:

- street vendors without fixed premises
- street vendors with rudimentary fixed premises.

In addition to the binary classification 'sedentary/non-sedentary', the intermediate category of 'semi-sedentary' was added to the 1992 census of establishment and informal sectors in Benin. The semi-sedentary category aimed at accounting for those activities undertaken in the streets but with a kind or appearance of rudimentary fixed premises, which provide not only self-employment but also, eventually, more-or-less permanent jobs to family members or other members of the labour force. The non-sedentary street-vendor may have a fixed place in the street, but has to remove the goods at the end of the day. The semi-sedentary street worker may leave his intermediary and final products on the spot.

Such structural changes in the characteristics of street workers imply that surveys on these types of workers need to come closer and closer to classical informal-sector surveys. They need to distinguish production, trade and service activities, and no longer consider street activities as a phenomenon that will disappear.

Two additional issues should be considered related to the differences between street vendors in rural and in urban areas:

1) Street vending is not only an urban phenomenon. Perhaps even more than in urban areas, in rural areas the non-agricultural labour force is located outside enterprises' premises. Vendors are particularly numerous along roads that cross villages or at the crossroads, and many farmers or family workers classified by primary activities of their main jobs are road vendors or market vendors for their second (annual or seasonal) jobs.

2) Trade and sales activities may concern goods produced by the same persons on their farms or in their homes, and this represents a conceptual and methodological difficulty in rural as well as in urban areas. Selling self-produced goods should not be considered an activity different from producing them, except if there is a kind of transformation (such as crushing the grains or cereals, but this will not be the case for fruit or vegetables) or if they have been carried long distances to be sold in market places. This is not a marginal point concerning the measurement of women's activities. It is probably an important source of underestimation of their contribution insofar as this contribution is limited to commercial margins and does not take account of the value added in the production process. This is important for a correct enumeration of street vendors, because many will have declared themselves as producers in household surveys while they will be registered as vendors in establishment censuses. This must be clarified through a set of questions in these latter operations.

Data collection methods

As already mentioned, the location or place of work is the main feature for identifying street workers. Population censuses have been able to provide information on the number of people involved in these activities insofar as these items have been included in the questionnaires, through a specific question, or at least as categories of

response covering occupation and status in employment (specifically own-account workers in status of employment). Further progress would require a more detailed classification of occupational statuses. Moreover, the international standard classification of occupations also identifies a category of hawkers and peddlers in commercial occupations, but it is relegated to the four-digit sub-category and as such is very rarely released in the official publication of the results.

A technique for estimating home-based workers and street vendors from the available sources is as follows: the residual obtained by comparing the results of a population census (or labour force survey if no census is available) and establishment census can be interpreted as consisting of outworkers or undeclared or non-registered workers in given branches of activity and as street vendors in other commercial branches. Until now, establishment censuses have been the most efficient means of capturing the street-vendor segment, when these operations decided to include them in their scope as in the three countries already mentioned (Niger, Guinea and especially Benin). If they have fixed places in the streets (tables or stools or even baskets), the enumeration is not difficult. In Benin, mobile street vendors, who often gather in a few places known by everyone, were enumerated in 1992 after a mass-media campaign. A vendor, once enumerated, was given a badge to avoid double counts. Mobile street vendors in urban Benin accounted for more than 40 per cent of the total number of street vendors (informal transportation being included in this figure).

Street vendors remain a major contradiction and possibly a black hole in mixed surveys, that is, the two-stage surveys that are meant to capture the various segments of the informal sector. In the first stage, a representative sample of households is selected and all own-account workers and employers in the informal-sector are enumerated for that sample. In the second stage, all economic units of these informal operators are surveyed with an establishment questionnaire and preferably on the worksite. While own-account workers are to be interviewed at their workplace, it is difficult or even impossible to find the workplace of street vendors. Based on their declaration within the household, they are usually interviewed at home, though their declarations are not checked by observation, leaving room for underestimation and misunderstandings.

This does not mean that mixed-household surveys are useless to measure the numbers and characteristics of street vendors. But they certainly need to be followed by in-depth surveys in the field and in establishments to prevent as much as possible the underestimation of these activities.

Figure 5.9: Questionnaire design for a special street-vendor survey

It is important to ensure that the design of the questionnaire for a street-vendor survey takes into account the main issues concerning the informal sector, and those relating to gender. In addition to the questions on location described…, the questionnaire should include the following topics:

a) demographic and socioeconomic characteristics of the person: age, sex, educational level, matrimonial status, family status (living with parents or head of household – it may be interesting to develop a complete household questionnaire which would detail size of family, occupational status of the head, number of persons employed, unemployed, at school, sources of income, etc.), geographical origin or place of birth, date of arrival.

b) biographic characteristics and previous job experience: rural to urban migration itinerary and various activities undertaken before entering the present job; comparative degree of satisfaction and level of income with the present situation; questions on the modalities of installation, help received from relatives, ease of entry or barriers and obstacles encountered due to the regulatory framework or other reasons should be put.

c) present activity: detailed description (type of goods or services sold), type of installation (see above). This section should be developed along the lines presented above.

Examples of questions follow:

i) Are you
- an independent own-account worker working alone: with other family workers (several hours a day, or only when you are absent) / with casual employees?
- associated with other persons on an own-account basis? (In such a case, develop questions on the type of association.)
- a wage employee? (In such a case, develop questions on the employer and the type of salary.)

ii) Do you (or your family) produce the goods you sell? (In such a case, develop the questions on production.)

iii) Do you buy the goods you sell
- from several shopkeepers or persons: always the same/ not always the same – from one single shop-keeper or person: always the same / not always the same (in such a case, does this person sell the goods to other street vendors like you)?
- from a big store?

iv) What are the conditions of purchase?
- at the same price as for any customer?
- are goods paid for when they have been sold?
- are goods consigned against payment of a fixed amount which will be completed after sale of the whole? (In this case, is there a charge for credit.)

v) At the end of the day (yesterday), how much have you sold?

vi) Have you deducted from this amount what you have paid
- for eating?
- for the needs of the family?
- for other needs?

vii) How much of this amount are you going to use to buy new goods to sell the next day?
- What do you do when you cannot save enough money to reconstitute the amount of goods you sell?
- What do you do when you save more money than you need to spend to purchase the goods you sell?

The major difficulty in trying to reconstitute the income earned from street vending is choice of the period of reference: if the day (or the week) will be the most adequate for the receipts and for personal and family consumption expenditures, the purchase of goods will probably require a different reference period.

Another important but easier question is the duration of work: number of hours per day, number of days per week, number of months per year. It is also important to ask what are the non-working months. This is to verify whether street vending is still associated with seasonal agricultural activity and whether it is related to rural-urban migrations. In Niger, for example, due to the intensity of rural-urban migration during the agricultural season, the authorities put street vendors on trucks returned them to their villages, where labour shortages were observed.

d) free entry and competition: these aspects of street vending are as important as the questions related to income because they are at the core of theories of development and the determination of policy interventions by the state, donor agencies and grassroots organizations.

While ease of entry continues to be a characteristic of street vending, street vendors have constant fights with authorities and competing vendors. As Victor Tokman put it (PREALC, 1988), street vendors must defend their sites against municipalities, established shopkeepers and other vendors who try to limit the number of entries. An important challenge to surveys on street vendors is to measure the degree of freedom and competition, and to identify the hidden barriers that keep the poor from developing their private initiatives.

Among various questions on these topics, three are emphasized here:

i) What conditions made it easy for you to begin vending and what conditions made it difficult?
   - completely free to set up?
   - received the help of other people (or vendors), and what kind of help?
     - from the family?
     - from the extended family?
     - from the village (or district)?
     - from the ethnic group?
     - from others?
   - had to make payments (in kind, in cash, in per cent of receipts,...) to
     - the agents of the municipality?
     - the agents of other administrations?
     - the established shopkeepers?
     - the other street vendors?
     - other individuals representing the shopkeepers, the other vendors, keepers or protectors of the street, the block, the district?
   - other payments?

ii) And if you have a place, is it easy or difficult to keep your site, and why?
   - various payments you have to make?
   - various obligations you have to respect?

iii) Among all these payments and obligations, which do you consider to be usual or natural, and which excessive or exorbitant?

The questionnaire should also cover the following topics:

e) urban policies and taxation: preparation of this section will require information on the various formal and informal taxes that street vendors have to pay.

f) Social insurance, traditional solidarities and social capital: how do street vendors manage when they fall sick or when they have an accident which prevents them from working? Can they rely on their traditional cooperative networks and are the investments they have made in this form of social capital more profitable and efficient than the payments they may make to informal protectors in the market? There are different means of measuring social capital (Charmes, 1998). A survey on street vendors – unless it is part of a household survey – will provide qualitative responses (rather than measures in terms of expenditures and time use) concerning the ways and means by which street vendors cope with the costs of social insurance and can rely on the social capital they have accumulated.

g) needs, organization and support: the last section of the questionnaire should deal with the wishes of the street vendors, how they imagine they will improve their working and living conditions and their means for doing so.

Source: Charmes, 1998b.

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Annex: Sources of gender-disaggregated data in science, engineering and technology

United Nations and international governmental organizations

Consultative Group on International Agricultural Research (CGIAR)

Gender and Diversity Program

The CGIAR is an association of public and private members supporting a system of fifteen agricultural research organizations known as the Future Harvest Centres.

The purpose of the Gender and Diversity Program is to help the Future Harvest Centres of the CGIAR to leverage their rich staff diversity and increase research and management excellence. It promotes such activities as diversity-positive recruitment, international teamwork, cross-cultural communications and advancement for women.

The Future Harvest Centres work in more than a hundred countries to mobilize cutting edge science to reduce hunger and poverty, improve nutrition and health, and protect the environment. The CGIAR Gender and Diversity Program provides those centres with services and resources to focused on supporting an organizational culture of inclusion, dignity, well-being and opportunity, in both policy and practice. Publications available include sex-disaggregated data on staff at CGIAR centres.

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Food and Agriculture Organization (FAO)

The Statistics Division of the FAO's Economic and Social Department provides a host of data relating to gender at the FAOSTAT website, under the 'Population' domain (http://apps.fao.org). The domain provides long-term series of demographic estimates and projections consisting of (a) quinquennial series of total population by gender and urban and rural population, and (b) decennial series of agricultural and non-agricultural population, total economically active population (labour force), gender, and economically active population in agriculture (agricultural labour force) by gender.

The Statistics Division also compiled data collected in the agriculture censuses conducted in eighty countries (Statistical Development Series no. 9) from 1986 to 1995. Among other details, countries were asked to compile data on holders, farm population and employment by gender. The Division provides guidelines for collection of data to the member countries.

Realizing the importance of gender-related issues in the process of sustainable agricultural development and the difficulties encountered in the availability and analysis of the data for use by policy-makers, the Statistics Divi-

sion is planning to approach the problem in a more comprehensive manner. The new approach will be to compile data from all sources (agricultural censuses and surveys as well as household income/expenditure surveys) to understand the role of women in social, cultural and economic development and their impact on income, consumption, nutritional status and so on. Thus, in addition to the traditional focus on the collection and compilation of data on status of holder, employment and population dependent on agriculture by gender, the new approach would attempt cross-classifications of the attributes by size of holding, income classes and others as well as to establish linkages with income and consumption levels. In this context it would be necessary to improve the existing concepts for data collection as well as to frame new methods for assessing gender contributions to income generation. It is also proposed to encourage member countries to retabulate existing data from censuses and surveys and to demonstrate their utility in decision-making.

FAO Gender Statistics
Food and Agriculture Organization (FAO)
Viale delle Terme di Caracalla
00100 Rome
Italy
Tel: +39 06 57051
Fax: +39 06 570 53152
www.fao.org/gender/en/statse.htm
apps.fao.org

Gender Advisory Board, UN Commission on Science and Technology for Development

The Gender Advisory Board (GAB) was established in 1995 to provide advice to the United Nations Commission on Science and Technology for Development (UNCSTD).

It has two principal functions. The first is to monitor the implementation of the recommendations made by UNCTD on gender and S&T, and, when requested, to provide assistance in their implementation. The second is to advise UNCTD on the gender implications of its new work programmes. The GAB also oversees activities that support national governments and UN agencies in implementing the Gender Working Group (GWG) recommendations, provides support and advice to agencies for mainstreaming gender concerns in S&T, and liaises with other UN agencies through the UN Development Fund for Women (UNIFEM).

UNCSTD made a series of recommendations to the United Nations Economic and Social Council (ECOSOC) on the gender and science issue were based on a report from the GWG, which UNCSTD established in 1993.

They were ratified by ECOSOC in July 1995. The main intention in setting up the GWG was to contribute to the discussions on S&T at the Fourth World Conference on Women and Development, which was held in Beijing in 1995.

Proscovia Njuki
Gender Advisory Board
UN Commission on S&T for Development
Association of Women Engineers, Technicians
and Scientists in Uganda (WETSU)
Bukoto Street, Plot 20, Lower Kololo
P. O. Box 21576
Kampala
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Tel: 256 41 541400
Fax: 256 41 541378
Email: proscovianjuki@gab.co.ug
proscovianjuki@yahoo.com
http://gab.wigsat.org
Gender Science and Technology Gateway:
http://gstgateway.wigsat.org

International Labour Office (ILO)

The ILO Bureau of Statistics works to provide users within and outside the ILO with relevant, timely and reliable labour statistics, to develop international standards for better measurement of labour issues and enhanced international comparability, and to help Member States to develop and improve their labour statistics. In doing so, it maintains professional relations with national statistical systems, especially central statistical agencies and ministries responsible for labour issues, and with statistics offices of other international organizations.

The Bureau's activities to meet its goals include: gathering and disseminating labour statistics, setting international standards and guidelines for labour statistics, and providing technical cooperation, assistance and training regarding labour statistics.

The ILO provides databases on:

- country and regional information
- labour legislation
- labour statistics
- occupational safety
- social security
- terminology
- vocational training and rehabilitation
- world of work.

International Labour Office
Bureau of Statistics
4, route des Morillons
CH-1211 Geneva 22
Switzerland
Tel: +41 22 799 8631,
Fax: +41 22 799 6957
Email: stat@ilo.org
http://www.ilo.org/public/english/bureau/stat/index.htm
http://www.ilo.org/public/english/support/lib/dblist.htm

Organization for Economic Cooperation and Development (OECD)

The OECD collects statistics needed for the analysis of economic and social developments by its in-house analysts, committees, working parties, and Member Country governments from statistical agencies and other institutions of its Member Countries. The OECD shares the experience gained by members in compiling reliable and comparable statistics with non-member countries.

From a substantive point of view, the Statistics Directorate (STD) is responsible for macroeconomic statistics (national accounts, short-term economic indicators, international trade, etc.) and for some social (e.g. labour force) and business statistics. The majority of other statistical activities within the OECD are carried out in eight directorates.

Most of OECD's statistical outputs are made available to the public through electronic and paper publications and through the Statistics Portal, with statistical tables in twenty-five topics: agriculture and fisheries, demography and population development, economic projections, education and training, energy, environment, finance, health, industry and services, information and communication technology, international trade, labour, leading indicators and tendency surveys, national accounts, non-member economies, prices and purchasing power parities, productivity, public management, science, technology and patents, short-term economic statistics, social and welfare statistics, statistical methodology, territorial statistics, and transport.

The Statistics Portal (www.oecd.org/statistics) provides free access to some OECD databases as well as extracts from all other databases, classified by topic.

OECD work in the field of gender-related education and STA and detailed references are presented in Chapters 4 and 5 of this toolkit.

OECD
2, rue André Pascal
F-75775 Paris Cedex 16
France
Tel: +33 1 45 24 82 00
Fax: +33 1 45 24 85 00
Email: stat.contact@oecd.org
http://www.oecd.org

UNESCO Institute of Statistics (UIS)

The UIS was established in July 1999 to meet the growing needs of UNESCO Member States and the international community for a wider range of policy-relevant, timely, and reliable statistics in the fields of education, S&T, culture and communication.

The UIS aims to: ·

- gather a wide range of quality statistical information to help Member States analyse the efficiency and effectiveness of their policy decisions and programmes
- interpret and report on the global situation with regard to education, S&T, culture and communication.

The UIS's current programme includes:

- conducting annual education surveys, to obtain a core set of quality education data, and providing training workshops in all regions of the world in support of the surveys
- working with Member States to implement the ISCED-97 (the revised International Standard Classification of Education) within their country
- developing the programme on World Education Indicators (WEI) in coordination with the OECD as

well as the programme for European Union candidate countries in cooperation with Eurostat
- supporting statistical capacity building within countries, including the Africa-wide Strengthening National Education Statistical Information Systems (NESIS) programme
- incorporating the EFA Observatory, the international monitoring body that examines progress towards the objectives of Education for All (EFA).
- UIS S&T statistics and indicators covers national data on human resources and expenditure in research and experimental development (R&D).

UNESCO Institute for Statistics
C.P. 6128 Succursale Centre-ville
Montreal, Quebec, H3C 3J7
Canada
Tel: +1 514 343 6880
Fax: +1 514 343 6882
Email: information@uis.unesco.org
http://www.uis.unesco.org

United Nations Statistics Division

The Statistics Division compiles statistics from many international sources and produces global updates, including the *Statistical Yearbook*, *World Statistics Pocketbook* and yearbooks in specialized fields of statistics. It also provides countries with specifications of the best methods of compiling information so that data from different sources can be readily compared.

The Division produces books and reports of statistics and statistical methods in international trade, national accounts, demography and population, social indicators, gender, industry, energy, environment, human settlements and disability. Many databases are available as electronic publications and data files on CD-ROMs, diskettes and magnetic tapes.

Unrestricted free access is provided to selected global datasets, such as the Millennium Indicators Database, which presents forty-eight social and economic indicators and related series by country and year since 1985, and the Social Indicators dataset.

Statistics Division,
United Nations
New York, NY 10017
United States of America
Fax: +1 212 963 4116
Email: statistics@un.org
http://unstats.un.org/unsd

United Nations Development Programme (UNDP)

In each *Human Development Report* (HDR), UNDP aims to stimulate policy debates and discussions on critical issues of human development by providing data and statistical analysis in various areas of human development.

Each HDR usually presents two types of statistics: the human development indicator tables, which – led by the human development index (HDI) – provide a global assessment of country achievements in different areas of human development (see Index to indicators), and thematic statistical analyses.

The HDR for 2005 incorporates many of the MDG indicators in the HDI tables (see Index to Millennium Development Goal indicators). Data for these indicators provide a statistical reference for assessing the progress in each country towards achieving the MDGs and their targets (see 'Statistical feature 1: The state of human development').

Human Development Report Office
304 E. 45th Street, 12th Floor
New York, NY 10017
United States of America
Tel: +1 212 906 3661
Fax: +1 212 906 3677

Statistical Unit (same address)
Tel: +1 212 906 3675
Fax: +1 212 906 5161
Full reports available at the websites:
http://hdr.undp.org/hdro
http://hdr.undp.org/statistics

World Bank GenderStats

GenderStats is an electronic database of gender statistics and indicators designed with user-friendly, menu-driven features. It offers statistical and other data in modules on several subjects. The data in each module is presented in

ready-to-use format. Users have the option of saving the country views in Excel (or another spreadsheet software) to customize them for their own reports.

GenderStats is updated continuously as new information becomes available. The database is a work in progress and its coverage has been expanded to include themes that range from health and education to political participation and poverty.

Sex-disaggregated data for some themes are limited. The database includes indicators for which sex-disaggregated data are in many cases unavailable to point out the importance of collecting such data in a disaggregated form. This often can be done at the source of collection.

Data sources for GenderStats include national statistics, United Nations databases, and World Bank-conducted or -funded surveys.

The World Bank
1818 H Street, N.W.
Washington, DC 20433
United States of America
Tel: +1 202 473 1000
Fax: +1 202 477 6391
Email: PREMAdvisory@worldbank.org,
Gnetwork@worldbank.org.
Gender Net: www. worldbank.org/gender
Gender statistics: http://genderstats. worldbank.org

Regional agencies

Asia Pacific Economic Cooperation (APEC)

Asia Pacific Economic Cooperation (APEC) is a government-linked association grouping the countries of the Pacific Rim areas of Asia and Latin and North America. The Gender Focal Point Network (GFPN) provides linkages for information-sharing and -support between APEC Foray, APEC Member Economies and the APEC Secretariat to advance the economic interests of women for the benefit of all economies within the APEC Region. The GFPN maintains and advances the implementation of the Framework and the work of AGGI in maintaining awareness of gender issues.

The GFPN comprizes Fora Gender Focal Points working with Economy Gender Focal Points assisted by the Program Director for Gender Integration of the APEC Secretariat. The APEC Business Advisory Committee (ABAC) and Women Leaders Network (WLN) are advisory bodies to GFPN.

It monitors implementation of the projects The Economic Contributions of Women and Men in APEC Economies, The Need for Sex-Disaggregated Data, and the Gender Resource Kit.

APEC Secretariat
Ms Monica Ochoa Palomera, Director
Gender Focal Point Network (GFPN)
35 Heng Mui Keng Terrace
Singapore 119616
Tel: +65 6775 6012
Fax: +65 6775 6013
http://www.apec.org/content/apec/apec_groups/som_special_task_groups/gender_focal_point_network.html
Email: mop@apec.org

European Commission/Eurostat Women in Science Initiative

Eurostat, which is the Statistical Office of the European Communities, provides the European Union with statistics at European level which enable comparisons between countries and regions. Over the last four years, Eurostat has mobilized a major effort to integrate sex-breakdown into R&D statistics, most notably in the legal basis and in the questionnaires since 2001. The Women and Science unit works closely and collaborates regularly with Eurostat colleagues from Unit B5 (Research) in their efforts to improve data quality and to source other areas of data, which are already available through the Eurostat statistical system (the structure of earnings survey and the labour force survey). Since October 2004, Eurostat has been disseminating all data for free through their website.

Contact:
European Commission
Research Directorate-General
Women and Science
Office SDME 06/79
B-1049 Brussels
Belgium
Fax: +32 2 299 37 46
Email: rtdwomenscience@cec.eu.int

She Figures 2003: *Women and Science Statistics and Indicators*: europa.eu.int/comm/research/sciencesociety/pdf/she_figures_2003.pdf.
Eurostat S&T statistics: http://epp.eurostat.cec.eu.int/portal/page?_pageid=0,1136250,0_45572564&_dad=portal&_schema=PORTAL

IberoAmerican and InterAmerican Network on S&T Indicators (RICYT)

RICYT promotes the development of instruments for measuring and analyzing S&T in Ibero America in a framework of international cooperation in order to achieve a better knowledge of S&T and its best utilization as instruments for decision-making.

RICYT convened a Central America Seminar Workshop on S&T Indicators with a Gender Approach 10–11 June 2004 in San Salvador, El Salvador. It was aimed at encouraging the elaboration of S&T indicators in the region, under a gender-centred perspective.

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Desarrollo y Educación Superior-REDES
Mansilla 2698 2º piso
(C1425BPD) Buenos Aires
Argentina
Tel: +54 (11) 4963 8811/7878
Email: ricyt@ricyt.edu.ar
http://www.ricyt.org

Standard national sources with breakdowns by gender

Overview: Types of available data

In many countries there are a number of regular data surveys with established (and regularly updated) time series of interest to gender analysis. Population (demographics), education and labour force (employment/unemployment) surveys and statistics are the principal sources of information. Education statistics have already been discussed in detail in Chapter 3 and in the international section above. Labour force/occupation statistics were also touched upon in Chapter 4. We should also be aware of the existence of other S&T-related statistics, such as medical/health data, which in some cases may provide sex-disaggregated information.

This section will briefly discuss a number of other types of survey at national level, which may provide information of interest to S&T gender policies. Most of these surveys are perhaps still more easily carried out in the industrialized regions of the world than in still developing economies embarking on statistics collection, but these categories should be privileged for data collection.

Employment/labour force surveys

Such surveys are usually annual and focus on the employment and occupational characteristics of individuals (allowing a breakdown by gender). They are often sample surveys, sometimes based on employer-reported information. Specific information on STP within the stocks and flows of total personnel will sometimes be 'blurred' when the sample information is 'grossed up' to total levels.

Population censuses

General population censuses are undertaken at regular (perhaps five- or ten-year) intervals. The census questionnaires may provide information on, for instance, family status (age and gender of family members) and their educational attainment or occupation (with some problems, however, due to the 'self-definition' of respondents). The main disadvantages are the long time intervals between censuses and the subsequent time needed (frequently several years) for processing the results. In many countries, censuses serve as a primary source of information on literacy/illiteracy.

Household surveys

Household surveys investigating specific features of, for instance, social and financial conditions and employment, are becoming regular statistical tools in many countries. They are usually carried out as annual sample surveys but sometimes even quarterly or monthly. Though with smaller statistical coverage than census surveys, information is often collected for more variables. The household survey results are more rapidly available than census data and this information may therefore be of high short-term policy interest.

Administrative registers of personnel

In some of the smaller European countries (for instance, in Scandinavia and Austria), there are public population or other registers (on state-employed personnel, for instance)

which, pending confidentiality constraints, may provide information on the S&T labour force. In some cases such registers are already replacing censuses as a basic source of information for government policies. Finland, Norway and Sweden have registers on the respective population's educational attainment (completed degrees). There are some special registers on the status of the S&T/R&D personnel force in the country, which allow detailed analysis of a number of variables, with gender as one of the principal ones. Such registers may still, with the constraints of confidentiality, be used to produce indicators, combining information from several databases or registers.

Migration statistics

Information about countries' patterns of emigration and immigration may be found via surveys or registers.

Trade and professional associations

The *Canberra Manual* suggests that trade and professional associations may compile data from their registers and carry out specific membership surveys on given topics, though it may sometimes be difficult for external users to gain access to such data.

Ad hoc surveys carried out by academic and related groups

Ad hoc surveys carried out by academic and related groups have proved to be efficient means of shedding light on gender disparities in S&T and notably in programmes and careers in education systems. In fact, such groups have provided most of the pertinent gender-related information to policy discussions in recent years.

Special gender indicators

As already mentioned in this toolkit, indicators eliminating distortions due to the size of the countries studied are preferable to data expressed as total numbers only. A number of such indicators and ratios used in UNESCO's *Practical Guide* were presented in Chapter 5. They were:

- the illiterate gender ratio
- the GPI
- the GER
- the SLE
- the SSE.

United States

Women, minorities and persons with disabilities in science and engineering

NSF, Division of Science Resources Studies
4201 Wilson Blvd., Suite 965,
Arlington, VA 22230
United States of America
Tel: +703 306 1780
Fax: +703 306 0510
http://www.nsf.gov/statistics/wmpd
Email: srsweb@nsf.gov

This series presents trends in the participation of women, minorities and persons with disabilities in science and engineering fields. Topics include higher education enrolments, degrees, institutions, and financial support and employment status, occupations, sectors, and salaries.

Women, Minorities, and Persons with Disabilities in Science and Engineering seeks to provide the most current information available. Rather than being a static report, the new format is a dynamic Web-based information source with data updated as they become available. This site is a starting point for finding information about the participation of women, minorities, and persons with disabilities in science and engineering education and employment. Its primary purpose is to serve as an information source; it offers no en0dorsement of or recommendations about policies or programmes. NSF reporting on this topic is mandated by the Science and Engineering Equal Opportunities Act (Public Law 96516). This site contains data tables organized by topic (e.g. undergraduate enrolment, graduate degrees, employment) and also by group (e.g. Hispanics, minority women, persons with disabilities). Presentation slides, which are charts in PowerPoint, graphic, and spreadsheet formats, are provided for easy downloading. Furthermore, links to additional data sources (e.g. National Centre for Education Statistics, American Council on Education) and reports on these topics are provided. A complete update of the report is issued every two years.

US primary non-NSF sources

Survey of Income and Program Participation

The Survey of Income and Program Participation con-

ducted by the Census Bureau provides information on the economic situation of households and persons in the United States. The survey collects data on basic social and demographic characteristics of persons in households, labor force activity, type and amount of income, participation status in various programmes, and various supplementary modules, for example, work history, health characteristics (including disability), assets and liabilities, and education and training.

Contact:
Current Population Reports
Bureau of the Census
U.S. Department of Commerce
Washington, DC 20233
United States of America
Tel: +1 301 763 8300

National Assessment of Educational Progress (NAEP)

The NAEP is sponsored by the National Centre for Education Statistics (NCES) and has been conducted since 1983 by the Educational Testing Service. The overall goal of the project is to determine the nation's progress in education. Accordingly, the NAEP encompasses a series of national sample surveys designed to assess students in ten subject areas, including reading, mathematics, science, writing, and history. Begun in 1969, the NAEP was conducted annually through 1980; since 1980 the project has been conducted biennially. The NAEP has surveyed the educational accomplishments of 9-, 13-, and 17-year-old students (and, in recent years, those in Grades 4, 8, and 12 as well).

Contact:
National Centre for Education Statistics
U.S. Department of Education
555 New Jersey Avenue, NW
Washington, DC 20208-5653
United States of America
Tel: +1 202 2191 761

American College Testing Programme

The American College Test (ACT) is taken by college-bound high-school students who request that the results be sent to designated colleges and scholarship boards. The ACT is designed to measure educational development in the areas of English, mathematics, social studies and natural sciences. The test results are used in part to help to predict how well students will perform in college. In 1994, approximately 892,000 students took the ACT.

Contact:
The American College Testing Programme
2201 North Dodge Street
P. O. Box 168
Iowa City, IA 52243
United States of America
Tel: +1 319 337 1510

Scholastic Assessment Test (SAT)

The Admissions Testing Programme of the College Board comprizes a number of college admissions tests, including the Scholastic Assessment Test (SAT). The SAT is taken by students who need the results to apply to a particular college or university or scholarship board. High school students participate in the testing programme as sophomores, juniors or seniors—some more than once during these three years. If they have taken the tests more than once, only the most recent scores are tabulated.

The SAT reports sub-scores in the areas of mathematics and verbal ability. Students may also elect to take Achievement Tests in any of twenty-one subject areas; these exams are generally taken by students who are applying to the more competitive schools. In 1994, approximately 1.1 million students took the SAT, and more than 200,000 took at least one Achievement Test.

Contact:
College Entrance Examination Board
Educational Testing Service
Princeton, NJ 08541
United States of America
Tel: +1 609 771 7600

The Integrated Postsecondary Education Data System Survey

Fall enrolment, completions and institutional characteristics

The Integrated Postsecondary Education Data System (IPEDS) began in 1986 as a supplement to and replacement for the Higher Education General Information Survey (HEGIS), which began in 1966. HEGIS was an annual survey of institutions listed in the current NCES

Education Directory of Colleges and Universities. IPEDS surveys all postsecondary institutions, including universities and colleges and institutions offering technical and vocational education. The higher-education portion is a census of accredited two- and four-year colleges, whereas technical and vocational schools are surveyed on a sample basis.

IPEDS consists of several integrated components which obtain information on types of institutions where postsecondary education is available, student participants, programmes offered and completed, and the human and financial resources involved in the delivery of postsecondary education. The components of IPEDS include surveys of institutional characteristics, fall enrolment of students (including their age and residence), fall enrolment in occupationally specific programmes, completions, finance, staff, salaries of fulltime instructional faculty, and academic libraries.

Contact:
National Centre for Education Statistics
Department of Education
555 New Jersey Avenue, NW
Washington, DC 20208-5652
United States of America
Tel: +1 202 219 1373

The National Postsecondary Student Aid Study (NPSAS)

The NPSAS was established by the NCES to collect information on financial aid allocated to students enrolled in US post-secondary institutions. The NPSAS was first administered in the fall of the 1986/87 academic year. NCES conducted subsequent cycles of NPSAS for the 1989/90, 1992/93, and 1995/96 school years. The 1989/90 cycle contained enhancements to the methodology used in the 1986/87 cycle. Estimates from the 1996/96 NPSAS sample are generally comparable to those from the 1993 and 1990 samples but not to those from the 1987 sample.

The 1995/96 survey gathered information from about 60,000 undergraduate and graduate students selected from registrar lists of enrolees at about 800 post-secondary institutions. The sample included students who did and those who did not receive financial aid, as well as students' parents. Student information, such as field of study, educational level, and attendance status (part- or full-time), was obtained from registrar records. Types and amounts of financial aid and family financial characteristics were abstracted from school financial aid records. Parents of students were also sampled to compile data concerning family composition and parental financial characteristics. Biennial follow-up data collections are expected.

Contact:
National Centre for Education Statistics
Department of Education
555 New Jersey Avenue, NW
Washington, DC 20208-5652
United States of America
Tel: +1 202 219 1839

US primary NSF sources

The following NSF sources were used for data tables in this publication. Published data tables from these surveys may be accessed on the NSF Web page (http://www.nsf.gov/sbe/srs). In addition, researchers may access the data directly through the SESTAT or WebCASPAR database systems on the Internet.

Survey of Earned Doctorates (SED)

The SED has been conducted annually since 1957. Until 1996, it was conducted, under contract with the National Research Council of the National Academy of Sciences, for the NSF, the US Department of Education, and the National Endowment for the Humanities, the National Institutes of Health, and the US Department of Agriculture. This is a census survey of all recipients of research doctoral degrees, such as PhD or D.Sc.; it excludes the recipients of first professional degrees, such as J.D. or M.D. Therefore, SED data are restricted to research doctorates.

Survey of Graduate Students and Post-doctorates in Science and Engineering

The data collected in the fall 1995 Survey of Graduate Students and Post-doctorates in Science and Engineering (GSS) represent national estimates of graduate enrolment and postdoctoral employment at the beginning of academic year 1995/96 in all academic institutions in the United States which offer doctoral or master's degree programmes in any science or engineering field. Included are

data for all branch campuses, affiliated research centres, and separately organized components, such as medical or dental schools, schools of nursing and public health. The survey universe consisted of 722 reporting units at 602 graduate institutions. Data are collected at the academic department level.

Available information includes full-time graduate students by source and mechanism of support, including data on women and first-year students enrolled full-time; part-time graduate students by sex; and citizenship and racial/ethnic background of all graduate students. In addition, detailed data on post-doctorates are available by source of support, sex and citizenship, including separate data on those holding first-professional doctorates in the health fields. Summary information on other doctorate non-faculty research personnel is also included.

Scientists and Engineers Statistical (SESTAT) Data System

In the 1990s, the NSF redesigned its data system about scientists and engineers. Termed SESTAT, the new data system integrates data from three NSF surveys (the Survey of Doctorate Recipients, the National Survey of College Graduates, and the National Survey of Recent College Graduates). The integration of the SESTAT surveys requires complementary sample populations and reference periods, matching survey questions and procedures, as well as weighting adjustments for any overlapping populations.

The surveys provide data on educational background, occupation, employment and demographic characteristics. These surveys are of individuals and have a combined sample size of about 105,000, covering a population of about 12 million scientists and engineers.

Argentina

Argentine network of gender, science and technology

S. Kochen, A. Franchi, D. Maffia and J. Atrio., 1998. *The situation of women in the technological and scientific sector of Latin America. The principal gendersensitive indicators.* Buenos Aires, Argentine Network of Gender, S&T (RAGCyT).
Email: skochen@mail.retina.ar).

International networks and professional organizations

International

Gender and S&T Association

c/o SATWAC Foundation
AI/22, Amrapali
Sukhipura, Paldi
Ahmedabad 380007
India
Fax: +91 79 6440359
Email: satwac@wilnetonline.net

Global Alliance for Diversifying the Science and Engineering Workforce

The Global Alliance is committed to increasing the participation of women in the SMET (science, math, engineering and technology) workforce worldwide and supporting other diverse groups including ethnicity, age, discipline, languages and cultures. Its primary objectives are twofold: (1) to establish worldwide collaborations with higher education institutions, corporations and governments, and (2) to facilitate the development of long-term, sustainable infrastructures in and for a diversified workforce.

http://www.globalalliancesmet.org

IEEE Women in Engineering (WIE)

WIE gathers and disseminates information regarding the status of women and initiatives for, by and on behalf of women in engineering and science; enables mentoring and education programmes within the IEEE (Institute for Electrical and Electronics Engineering) and makes available information regarding gender related educational issues which may improve women's entry into and retention in engineering programmes; increases the participation of women within IEEE; addresses ways to improve the climate for women in IEEE and the workplace.

Email: women@ieee.org
http://www.ieee.org

International Federation of Inventor's Associations (IFIA)
Women Inventors' Network (IFIAWIN)

Information and statistics on women inventors worldwide.

IFIA Secretariat
P. O. Box 299
1211 Geneva 12
Switzerland
Fax: +41 22 789 3076
Email: inventionifia@bluewin.ch
http://www.inventionifia.ch/women_inventors_ifiawin.htm

International Network of Women in Engineering and Science (INWES)

The aim of INWES is to have a significant voice, one that is heard by mainstream science and engineering on issues such as the environment, sustainable development, gender equity, and many other critical issues, and to state clearly and consistently our position and views in a united effort.

Contact:
Laval Université
Room Pouliot 1504
Quebec, G1K 7P4
Canada
Tel: +1 418 656 5359
Fax: +1 418 656 7415
Email: inwes@gmc.ulaval.ca
http://www.inwes.org

International Women in Science and Engineering (IWISE)

The goals of the IWISE programme are to enhance the status of professional women scientists from developing countries and countries in transition and to assist them in their efforts to improve conditions in their home countries. These goals are reached by providing women scientists with opportunities for collaboration in their scientific areas, leadership training, and support of projects they undertake which will improve the educational and social environments in their home countries.

Contact:
IWISE Programme
210 Lab of Mechanics
Iowa State University
Ames, IA 50011-2131
United States of America
Fax: +1 515 294 8624
Email: iwise@iastate.edu
http://www.iitap.iastate.edu/iwise/

Third World Organization for Women in Science (TWOWS)

TWOWS is the first international forum to unite eminent women scientists from the South with the objective of strengthening their role in the development process and promoting their representation in S&T leadership.

Contact:
Ms. Leena Mungapen
TWOWS Secretariat
c/o The Abdus Salam International Centre for Theoretical Physics (ICTP)
Strada Costiera 11
34014 Trieste
Italy
Tel: +39 040 2240321
Fax: +39 040 2240689
Email: info@twows.org
http://www.twows.org

Women in Global S&T (WIGSAT)

WIGSAT's mission is:

- to promote the contributions women make in S&T for development
- to promote knowledge-sharing concerning gender, S&T and gender, and ICT for development
- to help NGOs, governments, bilateral and multilateral agencies, and women themselves to understand the gender dimensions of S&T and the implications thereof for development policy and practice.

WIGSAT provides services in the area of gender, S&T for development, with a special focus on ICT. It also acts as a broker or disseminator of information and resources.

Email: shuyer@wigsat.org
http://www. wigsat.org

Regional

Africa

Federation of African Women Educationalists (FAWE)
P. O. Box 53168
Nairobi
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Tel: +254 22 26590
Email: fawe@fawe.org
http://www.fawe.org

Arab States

Arab Network for Women in S&T
http://www.agu.edu.bh/Arabic/ANWST/women/index.asp

Europe

European Association for Women in Science, Engineering and Technology (WiTEC)

Contact:
Ute Wanzek
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National

American Association for the Advancement of Science

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1200 New York Ave., NW
Washington, D.C. 20005
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India Women Scientist's Association (IWSA)

IWSA
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Association for Women in Science and Engineering

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Association for Women in Science (AWIS)

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Association of South African Women in Science and Engineering (SA WISE)

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7707 Rhodes Gift
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Women in Science Enquiry Network, Inc.

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http://www.wisenet-australia.org

Association for Women in the Sciences

Elizabeth Wells
AWIS, New Zealand

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Email: elisabeth.wells@chmeds.ac.nz
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Canadian Coalition of Women in Engineering, Science and Technology (CCWEST)
c/o Fletcher Wright Associates Inc.
6519-B Mississauga Road
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Canada
Email: info@ccwestt.org
http://www.ccwest.org

Association of Women Engineers, Scientists and Technicians of Uganda (WETSU)
Bukoto Street, Plot 20, Lower Kololo
P. O. Box 21576
Kampala, Uganda
Tel: +256 41 541400
Fax: +256 41 541378
Email: proscovianjuki@gab.co.ug
proscovianjuki@yahoo.com

Research institutions and programmes

Women in Informal Employment: Globalizing and Organizing (WIEGO)

Working Group on Statistics

WIEGO is a global research policy network that seeks to improve the status of the working poor, especially women, in the informal economy through better statistics, research, programmes, and policies and through increased organization and representation of informal workers.

Contact:
WIEGO Secreteriate
Harvard University
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79 John F. Kennedy Street
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United States of America
Tel: +1 617 495 0797
Fax: +1 617 496 9466
Email: info@wiego.org
http://www.wiego.org

UNESCO Regional Chairs 'Women, Science and Tecnology'
http://www.unesco.org/science/women/eng/index.html
Email: r.clair@unesco.org (Renée Clair)

UNESCO Women in S&T Chairs: Mujer, Ciencia y Tecnología en América Latina

The objectives of the Chair are:

- to promote and develop research projects on women's S&T in the Latin American region
- to train teachers and students in this field
- to raise awareness and inform the community about S&T issues and women's involvement in this area
- to encourage young women's professional development in S&T
- to mainstream gender-equity analysis into S&T policy planning and implementation
- to promote collaborative work among researchers, faculty, legislators, political leaders, entrepreneurs and women organizations in Latin America
- to exchange information and cooperate with international and regional organizations.

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Women and Science

European Commission

In most European countries, the number of female graduates is proportionately higher than that of male graduates. However, the scientific labour market remains male-dominated. Women face obstacles to their scientific work simply because they are women, and as a result, are under-represented in the sciences and in the decision-making bodies concerned with scientific issues. Achieving equal

and full participation of women in all scientific disciplines and at all levels will enhance diversity and promote further progress and excellence in European science. Achieving such a real and lasting change will go beyond women currently working in science, or aspiring to work in science, to help to create a more inclusive European scientific research area, for the benefit of the economy and society as a whole. Activities include:

- measures to ensure gender mainstreaming in the Sixth Framework Programme (FP6), from 2002 to 2006
- promoting networking among networks of women scientists in Europe
- generation of up-to-date statistics and indicators on women's representation in scientific disciplines
- research on how to support female research scientists working in industry
- evaluation of the current situation in the Eastern Europe and Baltic Countries, and to provide women scientists within these countries with support and tools for approaching policy-makers

Contact:
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Women and Science
European Commission
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Email: Nicole.Dewandre@cec.eu.int
http://europa.eu.int/comm/research/science-society/women-science/women-science_en.html

Websites and internet resources

Gender, Science and Technology (GST) Gateway

The GST Gateway was established by the Gender Advisory Board of UNCSTD to help policy makers implement the Gender Working Group recommendations for national S&T policy. It presents a range of resources, information, partners concerning gender and S&T for development. The recommendations are meant to address some of the gendered inequalities of S&T for development as it has been practiced to date. The site is organized by region and according to the seven critical areas for transformative action:

1. Gender equity in S&T education
2. Removing obstacles to women in S&T careers
3. Making science responsive to the needs of society: The gender dimension
4. Making the S&T decision-making process more 'gender aware'
5. Relating better with 'local knowledge systems'
6. Addressing ethical issues in S&T: The gender dimension
7. Improving the collection of gender disaggregated data for policy-makers.

It is aimed at policy-makers at all levels.
http://gstgateway.wigsat.org

UNESCO Women in Science

http://www.unesco.org/science/women/eng/index.html

Women-Related Science & Technology Resources, Centre for Women and Information Technology, University of Maryland, Baltimore County

A comprehensive, annotated and frequently updated site containing sections on Women's Studies/Women's Issues Resource Sites and Gender-Related Electronic Forums. It includes many links to sites focusing on women or girls and IT and S&T, and to email forums devoted to those issues.

http://www.umbc.edu/cwit/index.html
http://www.umbc.edu/cwit/sci_tech_resources.html

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Gender Indicators in Science, Engineering and Technology — ISBN 978-92-3-104038-2 — © UNESCO 2007

Science, engineering and technology are increasingly recognized as pivotal to sustainable socio-economic development, poverty reduction and other United Nations Millennium Development Goals. Yet most countries appear to be facing a decline of enrolment – especially among young women – in science and engineering. This, and brain drain, could have a serious impact especially on developing countries.

Efforts promoting women's participation contributed to increasing enrolment in the 1980s and 1990s up to 20–25% in many countries. Since 2000, however, these numbers appear to have declined to 10–15%, while in some countries women's enrolment is even lower.

More women and under-represented groups are needed in science and engineering to help maintain and promote our knowledge societies and economies, and not simply on grounds of equity alone. Already, the way in which science, engineering and technology data are predominantly collected renders women and their concerns, issues and responsibilities relatively invisible. But this is not the only reason that women remain under-represented in science and engineering. How many scientists and engineers are needed, in which fields and at what levels? What are the reasons for the recent decline of youth interest and enrolment in science and engineering? Gender issues in science and engineering, as in other areas, are an issue for us all, not just a problem for women.

This UNESCO toolkit on *Gender Indicators in Science, Engineering and Technology* aims to provide a better understanding of the numbers and needs at stake in these fields, including quantitative and qualitative indicators for the participation of women and under-represented groups, especially in developing countries. It reviews the main theoretical and methodological approaches to data collection internationally and presents case studies, guidelines and new approaches related to the collection and analysis of gender-disaggregated data. In so doing, it establishes a new basis for evidence-based analysis enabling planners and policy-makers to address these issues with greater effectiveness.

www.unesco.org/publishing

United Nations Educational, Scientific and Cultural Organization

Natural Sciences Sector
Basic and Engineering Sciences

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GENDER INDICATORS IN SCIENCE, ENGINEERING AND TECHNOLOGY

Sophia Huyer and Gunnar Westholm