4 Selected Issues in Science and Technology: The Gender Dimension

Introduction

This chapter explores selected issues in science and technology where a gender perspective provides a fresh way of viewing and formulating public policy. Looking at science and technology through a gendered lens means examining perceptions, practice, policy, impacts and beneficiaries. In doing so, it raises a number of questions: What are the perceptions of science and technology that lead to gender biased practice and policy? And how do gender biases in practice and policy affect perceptions in their turn? How do science and technology policies and programmes impact differently on the lives of women and men? What constitutes scientific knowledge? Whose knowledge has value and who decides what it is worth? Does knowledge have to be validated by science in order to have worth? And how can we promote a greater respect for various knowledge systems? (IWTC, 1997).

Women are usually portrayed as playing a passive role as the beneficiaries of science and technology. In fact, however, women have always played a major role in this area, both as inventors – of the cotton gin, fire escape and snugli, to name just three disparate and practical examples – and as practitioners in their everyday lives (Carr, 2000). A UNIFEM study, conducted in preparation for the 1999 UN World Conference on 'Science for the Twenty-first Century: a New Commitment', provides numerous case studies of women's activities, contributions, inventions and innovations (UNIFEM, 1999). These include women's work in formal and applied science and technology, but also highlight the fact that science is not just something that takes place in a laboratory and technology is not just hardware. Rather, science and technology also take place at the community level, for example when women select plants for breeding or manage energy and other natural resources in the household.

Governments advancing gender considerations in science and technology often stop short. They attempt only to 'add women in,' designing programmes for the recruitment, retention and promotion of women to redress historic imbalances. While this strategy is important, a wide range of challenging and compelling issues reaches well 'beyond the numbers'. These broader issues shift the analysis and emphasis from 'science by whom?' to 'science for whom?' For example, what type of health science is being publicly funded? For whose benefit? In science departments, are the outcomes of research and development priorities targeting women and men in an equitable manner? In technology and trade departments, do business programmes address the specific challenges of women entrepreneurs such as inequitable access to technology, venture capital and trade opportunities? Left unattended, the absence of policy in these areas will ultimately undermine any government's attempts to achieve a constructive, inclusive and lasting approach to sustainable and equitable development.

Appreciating the gender dimension across a broad range of science and technology activities can reveal biases and open opportunities to shape a stronger science policy

for the country. This chapter explores the following issues for their gender implications and suggests steps for addressing inequities:

- Local and Indigenous Knowledge Systems
- The Environment and Sustainable Development
- Agriculture, Biodiversity and Food Security
- Science and Technology, Education, Careers and Decision-making
- The Differential Impacts of Science and Technology
- Biotechnology and Ethical Issues
- Information and Communication Technologies (ICTs)
- Habitat Development
- Natural and Human-Created Disasters

It is important to note that race, ethnicity, class, physical ability, sexuality and age, among other factors, may add a level of complexity to the analysis and to the suggested solutions.

Cutting across all gender mainstreaming initiatives is the need for governments to commit to the systematic and comprehensive collection of sex-disaggregated data. Numerous international fora have remarked on the lack of adequate quantitative and qualitative data on women. This is equally the case in the area of science and technology. The way in which data in science and technology are collected can render women and their issues relatively invisible. At least two sets of data on women are essential for policy-makers: data on participation rates in scientific education and careers and decision-making; and data on the differential impacts on women and men of policies, programmes and priorities.

General Recommendations

- Ministries responsible for science and technology should implement international commitments on gender and science and technology in collaborative co-ordination with the National Women's Machinery (NWM) or agencies dedicated to women's equality.

- The NWM should be strengthened and situated at the highest possible level within government to demonstrate the government's political commitment to achieving gender equality and equity of outcomes. NWMs should be provided with adequate human and financial resources and technical support.

- Governments should put in place institutional structures and mechanisms to integrate gender into all policy-making, planning and implementation processes as set out in their National Gender and Development Action Plan and regularly monitor and evaluate the implementation and impact of the National Plan.

- Training in Gender-Based Analysis (GBA) should be a key strategy integrated into all aspects of policy and programme development, and systematically applied in a manner similar to environmental impact analysis, to ensure that gender mainstreaming takes place. System-wide gender sensitisation and training should be an ongoing process, made available to Gender Focal Points, staff in the NWM, other officials in the wider government structure and key stakeholders, including national/regional research and training institutes and training programmes.

- Monitoring and evaluation of gender awareness in government policies, plans and programmes should be carried out in all science and technology-related sectors, through the use of specially designed tools and instruments, such as gender policy appraisals, gender-aware budgets and gender impact assessments.

- The Commonwealth Secretariat should provide a range of training and resource materials for governments in the area of gender mainstreaming, such as the Gender Management System series, including guidelines for engendering governments' sectoral policies and programmes, and their financial and administrative procedures.

Local and Indigenous Knowledge Systems

Counting women who participate in science and technology usually stops at quantifying only those who participate in the formal, paid economy. Little if any attention is given to women's innovations and scientific contributions in the informal sector. Yet millions of women world-wide, particularly rural women, possess indigenous technical knowledge and practice science every day of their lives. This technical knowledge frequently underpins the food security of the family. As the UNCSTD Gender Report noted, modern science has not adequately recognised the value of local knowledge systems, nor addressed how best to protect and reward communities that have developed these systems over time. The UNESCO Declaration on Science and the Use of Scientific Knowledge and the Science Agenda, which came out of the 1999 UN World Conference on Science also states that:

"It is essential that the fundamental role played by women in the application of scientific development to food production and health care be fully recognised, and efforts made to strengthen their understanding of scientific advances in these areas."

Many activities, such as using a herb to salve a wound, planting certain crops together to deter pests, or cooking a poisonous plant in such a way as to render it harmless are the result of a systematic process of observation, experimentation and adaptation over time. Women are also responsible for many agricultural and environmental innovations including the development of housing materials, the breeding of animals and plants to accentuate qualities, energy technologies, soaps, textiles and medicines. Like other scientific systems, local knowledge systems have developed technology that improves the quality of people's lives. However, they differ from modern science and technology in that they are managed by the users of the knowledge and are holistic (Appleton *et al.*, 1995). Among other distinguishing characteristics, local knowledge systems are rarely supported by public funding, rarely patented or protected by intellectual property rights, not written down and published in scientific journals and not developed for purposes of commercialisation and export.

Frequently, when women's knowledge is seen to be valuable, it is taken over without recognition or remuneration by local or international companies and corporations which make huge profits through the commercialisation of knowledge which is not their own. There is a growing debate over the 'bioprospecting' of multinational drug companies in rainforests in their search for plants and animals for new pharmaceutical products and medicines. While some point to the potential for the development of new medicines that could assist in the fight against disease, others argue that bioprospecting will lead to further exploitation of natural resources to the benefit of multinationals and detriment of developing countries and local communities (IWTC, 1997).

It is estimated that at least 7000 medical compounds used in Western medicine are derived from plants, while more than two-thirds of the world's plant species, at least 35,000 of which have medicinal value, come from developing countries (WEDO, 1995). Knowledge about the properties of these plants is generally found in the communities where they grow. The TRIPS (Trade-Related Intellectual Property Rights) Agreement of the World Trade Organisation (WTO) allows for patents or

ownership claims to life forms, and thus to bioresources, including human genetic material.

Although technically most countries do not allow patents on plants, parts of plants such as genes, cell lines and characteristics are patentable. An example of this is the Neem tree in India, which has been used by women farmers for generations to treat skin infections, control pests and in many other ways. It now has 35 patents in Europe and North America. Similarly, American scientists have isolated a protein from brazzein, a West African berry traditionally used as a sweetener, which they plan to patent and develop into a US$100 billion a year market (Carr, 2000). In many places, such as the Pacific, where the culture is based on joint ownership and sharing, visitors to villages who request botanical material to take home are provided with it gladly. Given the current state of negotiations, it is unlikely that any benefits will accrue to the countries or communities from which the knowledge originated, least of all to the rural women responsible for passing much of the knowledge from generation to generation. This use of local knowledge has been referred to as 'biopiracy'.

Box 4 **Inventing and Adapting Food Production and Processing Technologies (Zimbabwe)**

In 1957, the Tonga of north-western Zimbabwe were moved to another region because their valley was going to be flooded by a hydroelectric scheme. Soil conditions at the new site were poor, rainfall was low and hunting was prohibited. People were initially unable to produce sufficient food to feed their families, but the Tonga women invented and adapted food production and processing technologies and identified new sources of food. These include 47 indigenous plants whose leaves are used for relish and over 100 tree species with a variety of edible plants.

One of the plants is the tamarind, which was previously relatively unknown in Zimbabwe. The fruit has some nutritional value and can be stored for up to 12 months. The Tonga women process and use tamarind as:

- a flavouring in sorghum or millet porridge (the fruit or leaves);
- a substitute for commercial beverages such as tea and coffee, which are expensive or unavailable (ripe or unripe fruit);
- a snack (the seeds);
- a substitute for or supplement to scarce maize, sorghum or millet meals (the seeds);
- a medicine (concentrated juice is used for gastrointestinal disorders and is thought to cure sleeping sickness); and
- a coagulant (the juice is used to curdle fresh milk).

Tamarind and other fruits are also traded for clothing with agents from outside the area.

Source: Appleton et al., 1995

The prospect of losing control over a crop that they grow, process and sell on a small scale can prevent women from taking advantage of the commercial possibilities of their labour. An example of this is shown by the experience of Tonga women of Zimbabwe (see Box 4). They invented and adapted food production and processing technologies, particularly in the use of tamarind. However, they were prevented from going into large-scale commercialisation by their fear that the fruit would no longer be available to them as a subsistence crop (Appleton *et al.*, 1995). On the other hand, the case of shea butter provides an example of how women can be assisted in order to

benefit from their own knowledge and skills. The butter is made from shea nuts collected by women in West Africa and used traditionally in cooking, as a skin cream and for medicinal purposes. It is also exported to Europe and Japan for use in the making of chocolate, margarine, cosmetics and pharmaceuticals. Seeing the growing demand for this product both locally and internationally, UNIFEM helped women producers to organise themselves into a network in order to access larger markets and negotiate better prices for themselves (Elson, 2000)

Women should be able to reap the benefits of their own scientific and technical knowledge and skills. Their role as intermediaries between the natural environment and society – for example, with regard to food security, sanitation and as producers, users and managers of energy resources – also needs to be valued.

Box 5 **An Indigenous Food Programme (Kenya)**

A programme that challenges traditional stereotypes of women as passive recipients of technology and projects the reality of them as knowledgeable, innovative partners in agricultural extension is the Indigenous Food Programme in Kenya. Based on the belief that women's knowledge of indigenous food plants is essential to sustainable solutions to malnutrition and food insecurity, the programme builds on their knowledge and skills and provides support to improve their existing food processing technologies. Women have established a seed bank, collecting, drying and packaging seeds for their own use and for sale, and have worked with partner organisations to create a data base of food plant species.

Source: International Women's Tribune Centre, 1997

Recommendations

- Ensure the preservation of local knowledge systems with attention to their gender-specific nature.
- Acknowledge the contributions of local knowledge systems to other science and technology systems, giving particular recognition to their gender-specific characteristics.
- Promote mutually beneficial exchanges between modern and traditional knowledge systems and technologies for the benefit of both women and men in rural areas.
- Address the ability of present regulatory and legislative systems to protect local knowledge owned by communities, paying special attention to its gender-specific nature.
- Where external agencies have exploited local knowledge systems for commercial gain, find mechanisms for compensating the women and/or men in communities who generated this knowledge.

'Transformative Actions' endorsed by the UN Commission on Science and Technology for Development, 1995

The Environment and Sustainable Development

"Greater attention to environmental health, especially women's environmental health, in all science and technology development interventions, is essential for sustainable development."

UNGCSTD, 1995

Women's health and environmental health are closely linked. Women's roles in the use of water, preparation of food, and tending of the sick all reveal that they possess considerable knowledge about how to use the environment in a sustainable way. At the same time, however, women's health can be threatened by changes to their local

environment resulting from such things as the introduction of irrigation schemes, hydroelectric dams, monocropping, pesticides and herbicides (Kettel, 1995a). Findings presented at the 1998 World Renewable Energy Congress meeting in Florence, Italy, showed that women are the group most affected by energy scarcity and related environmental degradation, both economically and through negative health impacts.

Women (and children) are also more exposed to the 'indoor air pollution' that comes from burning coal, wood and other fuel for cooking and heating, leading to problems such as lung disease, acute respiratory infection, lung cancer, adverse pregnancy outcomes, chronic bronchitis, and eye conditions (Farhar, 2000). *Energia News*, the newsletter of the International Network on Women and Sustainable Energy has pointed to the fact that 'in most developing countries, cooking is a major, if not the major, use of fuel'. The editors conclude that improved cooking technology would reduce women's fuel gathering burden, conserve energy and lead to better health (Issue 2, May 1997).

Women and men may have a different focus and level of awareness with regard to the eco-systemic associations that link various aspects of nature. Research carried out by the WEDNET team in Africa suggests that environmental perceptions are often gendered, and that the elements of the natural environment known and valued by women and men may be different, regardless of the cultural or regional setting (Kettel, 1995b). The gendered nature of people's perceptions about the environment is not limited to knowledge of different plant and animal species. It is reflected in the prevailing gender-based division of labour, in the various responsibilities and rights that women and men have in the use and ownership of land, trees, animals, plants, and water, and in the different knowledge of particular natural resources and ecological zones.

Ironically, while women own only one per cent of the world's land and have fewer economic rights than men, they play a vital role as the primary managers of both environmental resources and community life (Wee, 1995a). A recent ECOGEN case study, for example, reported that women in Kenya played a central role in helping their community survive a drought that sent every resident into the fields and hedgerows to scour the natural environment for food. Women, as the majority of the poor people of the world, have the biggest stake in protecting the natural resources that provide the basis of their livelihood. They are also less likely than men to have access to alternative economic opportunities.

Over the last few decades, a great deal of scientific research and technological innovation has been devoted improving living standards and raising incomes. Science and technology have allowed the constant testing of nature's limits in pursuit of ever greater efficiency, productivity and profits. However, two profound dilemmas have arisen.

- Many of these scientific and technological interventions, no matter how well meant, have been limited in their success and, all too often, ultimately detrimental to the sustainability of the natural environment. In spite of all the scientific and technological effort, women's poverty, especially compared to men in their own households and communities, has continued to rise.

- Women have been disproportionately exposed to the consequences of environmental degradation, in both rural and urban areas, particularly through their activities in the collection of fuel wood and water, the production of food crops, and through their work in the maintenance of homes and neighbourhoods.

Ignoring the perspectives of women, who are more closely connected with the environment, may mean that the resulting science and technology may not be the

most appropriate for sustainable development. In fact, the invisibility of women's 'landscape' in scientific and technological research and application has had profoundly negative impacts on women's income and well-being. Nature has been viewed through only one eye, and with one side of the collective human brain. Careful use and sustainable management of local – and planetary – ecosystems, however, requires full human sight and insight.

The failure of development planners, scientists and technological innovators alike to recognise that women may see and understand the natural environment differently from men, and have very different interests and goals in the use and management of their local environment, has also had a profoundly negative effect on the sustainable management of local ecosystems. Policies on environmental conservation do not usually take into account the different impact that they will tend to have on women and men and therefore the livelihoods of the communities. For example, policy makers have generally not recognised that deforestation has multiple impacts on women, who typically use forest products as food, fuel, fodder for livestock and medicine. This lack of gender awareness has led to reforestation schemes that have advocated the planting of trees such as eucalyptus which do not provide women with these resources (Wee, 1995a).

Women's views and goals generally include the welfare of three generations, including their children and care giving for older generations. This inter-generational appreciation and accountability, a care ethic embodied in women's work and perspectives, should be accorded comparatively greater weight than the male-derived policy framework currently driving science and technology systems – including the war machinery industry – in the global quest for a sustainable human future. Women's advice and knowledge about cooking, water, food, medicine, and their roles in energy supply and use, can be actively used to improve the effectiveness of sustainable energy technologies and to support sound economic development that improves the quality for families, communities and for the women themselves (Farhar, 2000).

Recommendations

- Take women's environmental health as a starting point for ensuring the appropriateness of all science and technology interventions.
- Use science and technology in a gender-sensitive manner to alleviate women's poverty through research and policy to meet their expressed environmental perceptions, needs and interests.
- Support women's microenterprise activities through environmentally sound and relevant science and technology interventions.
- Ensure women's environmental literacy through their increased access to formal and informal environmental education, and to relevant science and technology expertise and information, as a basis for their increased participation in community-based environmental decision-making.
- Support women's participation in national-level environmental decision-making.

Source: UNCSTD-Gender Working Group, 1995

Agriculture, Biodiversity and Food Security

Gender plays an important role in agricultural production, and involves factors such as who has property rights, who has control, who has access to what, and who does what work (Muntemba and Chimedza, 1995). Although women make up the majority of agricultural workers, only a minority of them have title to the land they work. Agrarian reform programmes of resettlement and land distribution have often failed to recognise the land ownership rights of women heads of household, married women and women

producers with partial or temporary land rights. Women may also be prevented from owning or inheriting property by discriminatory state or customary property and inheritance laws and policies. This in turn limits their access to credit since they have no title to use as collateral.

As predominantly small farmers, women have been largely responsible for activities such as the selection, improvement and adaptation of plant varieties. Women are most frequently solely responsible for the household's subsistence food production and the food security of the family. 'The significant roles that rural women play in the economic survival of their families' is specifically mentioned in the Convention on the Elimination of All Forms of Discrimination Against Women. The partnership between women and biodiversity has kept the world fed through history, and it needs to be preserved and promoted to ensure food security.

Agriculture based on diversity, decentralisation and improving small farm productivity through ecological methods is nature-friendly. Knowledge is shared and other species and plants are seen as kin, rather than 'property'. Sustainability is based on renewal of the earth's fertility and renewal and regeneration of biodiversity and species. While it has become clear that in many countries women comprise the bulk of the labour in agriculture, little has been done practically to ensure that women and their indigenous (or local) knowledge are included in key decision-making processes related to technology definition, development and adaptation. This has far-reaching and potentially harmful implications not only for the broader socio-economic environments, but also for the conservation and sustainable utilisation of agricultural biodiversity.

Typically, rural development efforts focus on incorporating 'modern' science approaches and technologies into policies and programmes, primarily through the transfer of technologies, such as the introduction of hybrid cash crops. For many socio-cultural, economic and historical reasons, these efforts tend to favour better-off rural men, and marginalise poorer rural women. Often, because these crops are not native, they are outside women's knowledge. Cash crops also compete with food crops and receive priority in terms of land and capital investment and labour (Muntemba and Chimedza, 1995). The threat to biodiversity is a real one: over the last century the rapid expansion of industrial and Green Revolution agriculture, with relatively few crop varieties cultivated in monocultures, have resulted in the disappearance of more than 75 per cent of agricultural crop varieties. With the disappearance of harvested crops goes a wide range of unharvested species and 'wild' foods essential for food provision, particularly in times of crisis (Mulvany, 2000). In failing to listen to community wisdom and investigate existing gender-differentiated knowledge and skills, technical experts, planners and policy-makers risk losing the diverse food production systems that conserve farmers' varieties of crops and breeds of domestic animals which form the genetic pool for food and agriculture in the future.

In the global knowledge-based economy powered by corporate competition and trade liberalisation, indigenous knowledge has become the focus for heated discussion in many fora on Intellectual Property Rights (IPR), most notably the WTO Trade-Related Intellectual Property Rights (TRIPS) and the Convention on Biological Diversity (CBD). For the most part, the gender implications of such negotiations have been left off official agendas. NGOs, farmers' groups and indigenous peoples' groups are often the only voices arguing for the need to consider socio-economic contexts as well as gender issues in the negotiations.

Genetic engineering is altering the way that agriculture is practised. The most widespread application of genetic engineering in agriculture is herbicide resistance, i.e. the breeding of crops to be resistant to herbicides. When introduced to farming systems in developing countries, this technology leads to increased use of agri-chemicals

Box 6 **The Sustainable Utilisation of Biodiversity for Economic Benefit (Kenya)**

In 1991, the National Museums of Kenya (NMK) was designated the National Centre for Biodiversity. Recognising the central importance of rural communities, especially women, in biodiversity conservation, the NMK initiated the Kipepeo Project, a butterfly farming project which is geared towards the sustainable utilisation of biodiversity for economic benefit. The project is based in the Arabuko Sokoke Forest, the largest remaining block of indigenous coastal forest in East Africa, which contains high biological diversity including over 250 butterfly species.

It is now widely recognised that the sustainable use of wildlife is a major motivating force for conservation particularly amongst the economically deprived people in developing countries. The two primary objectives of this project are to raise the economic status of the people living along the forest and to enable the community realise the benefits of conservation. Households are supplied with butterfly larvae and bags made of netting material. The women farmers tie bags in the leafy branches of food plants in the forest near by or in their compound, then change the bags to other branches when leaves are eaten up. About a month later the caterpillars change to pupae, which are then bought from the farmers and exported.

The project has had a number of benefits. The additional revenue that it has brought into the households is not only going towards sustaining families, but also towards future investments such as children's education or animal husbandry. Employment to a small extent has been raised. The project also brings the village women together as a group and, in turn, they have begun to engage in other conservation activities such as the establishment of tree nurseries so as to eliminate forest dependence for poles, fuel wood, fodder, etc.

thus adding to environmental problems. It also diminishes the biodiversity that is the sustenance and livelihood base of rural women. What are weeds for the producers of herbicides are food, fodder and medicine for women. In India, women use 150 different species of plants for vegetables, fodder and health care. In West Bengal, 124 'weed' species collected from rice fields have economic importance for farmers. In the Expana region of Veracruz, Mexico, peasants utilise about 435 wild plant and animal species of which 229 are eaten. The spread of herbicide resistant crops would destroy this diversity and the value it provides to farmers. It would also undermine the soil conservation functions of cover crops and crop mixtures, thus leading to accelerated soil erosion.

Women farmers do not generally buy seeds to grow basic foods but rather save them from one year to the next, selecting those that show desirable traits, such as hardier plants that are resistant to disease. IPRs on seeds have the potential for making seed saving and seed exchange illegal. The attempt to prevent farmers from saving seed is not just being made through new IPR laws, but also through the new genetic engineering technologies. A seed has already been patented which has been genetically engineered to ensure that it does not germinate on harvest, thus forcing farmers to buy seed at each planting season. Termination of germination is a means for capital accumulation and market expansion. The so-called 'terminator technology' provoked significant public outcry and rural women's NGOs were among the leading voices of concern.

Genetic engineering and IPRs can rob women of their creativity, innovation and

decision-making power in agriculture. In place of women farmers deciding what is grown in fields and fed to families, agriculture based on globalisation, genetic engineering and corporate monopolies on seeds has the potential to establish a food system and worldview in which global corporations control what is grown in the fields and what is eaten. In contrast, it is the diversity of local knowledge systems and production systems that has traditionally sustained subsistent family farming strategies where women in the developing world continue to play a central role in food security.

Recommendations

- Negotiate for trade-related and environmental agreements that protect women and men farmers' and indigenous peoples' knowledge and ensure agricultural biodiversity through the active participation by women, small-holder farmers and indigenous peoples as partners, decisions, and beneficiaries.
- Recognise and value women and men farmers' knowledge, skills and practices and promote policies and projects that facilitate enabling environments for the inclusion of indigenous knowledge through the adoption of gender-responsive participatory planning, implementation and evaluation processes.
- Redirect agricultural policy towards women centred systems, which promote biodiversity based on small farm agriculture.

Education, Careers and Decision-Making

Action agendas on issues of gender in science and technology often begin with the initial question: 'Science by whom?' Who is studying science? Who is entering science careers? Who is staying? Who is at the table of science and technology decision-making? This is an understandable starting point. A glance at the portraits in the foyers of Ministries of Science and Technology and National Research Centres or a visit to government departments of science, technology and industry renders visible the stark absence of women, particularly in places of position and power in science and technology public policy. The gender gap is visible and tangible.

Recognition of this under-representation of women in science and technology has ushered in analysis and action on two levels. First, research has focused on the school system. Placing the lens on the education pipeline has revealed a number of barriers and challenges to girls that curtail their entry into school, their choice of the science stream and their desire to stay studying science at advanced levels. Secondly, research has focused on women in the science and technology workplace. Placing the lens on careers has revealed a series of systemic barriers in science and technology, not only at the point of employment entry but also at various points throughout the career cycle. Both areas of analysis illustrate the need for a broad attitudinal change (see Box 7).

Science and technology education

A range of factors undermine girls' access to the school system and their subsequent pursuit of science and technology streams of study. At one extreme, obstacles may be rooted in written regulations that restrict the entry of girls into technical or vocational fields. For example, the syllabus of some veterinary medicine schools only decades ago designated a small fraction of admission spots for 'foreigners and women'. In a less overt way, access to schools may be denied to girls because of the absence of funding.

When forced to choose who in the family should receive an education, the preference to train boys rather than girls often prevails in resource-poor countries. Two-thirds of the world's illiterate are women.

Box 7

An Ambitious Strategy for Change (Canada)

In their first gender report, published in 1993, the National Advisory Board on Science and Technology (NABST) in Canada called for a broad attitude change with respect to women's contribution in the scientific and technical fields. The report contended that women were the single most under-utilised resource in the science and technology sector in Canada, and emphasised the importance of the full incorporation of diverse perspectives in science and technology as fundamental if the field is to flourish. It stated that:

- A quality work-force would only be achieved when the potential of the population was maximised by encouraging students of both genders to pursue studies and careers which not only respond to their best ability but also take them to the highest possible level of education and career attainment.
- Every sector of the population must be fully utilised and valued for the diversity it contributes, since diversity and differing perspectives in research, science and technology would foster innovation and a vibrant climate.
- The methods of instruction in educational institutions must respond to the varying approaches to learning demonstrated in different populations in society and by women and men.

NABST contended that the achievement of widespread awareness and effective action on issues of gender in science and technology required the following key components:

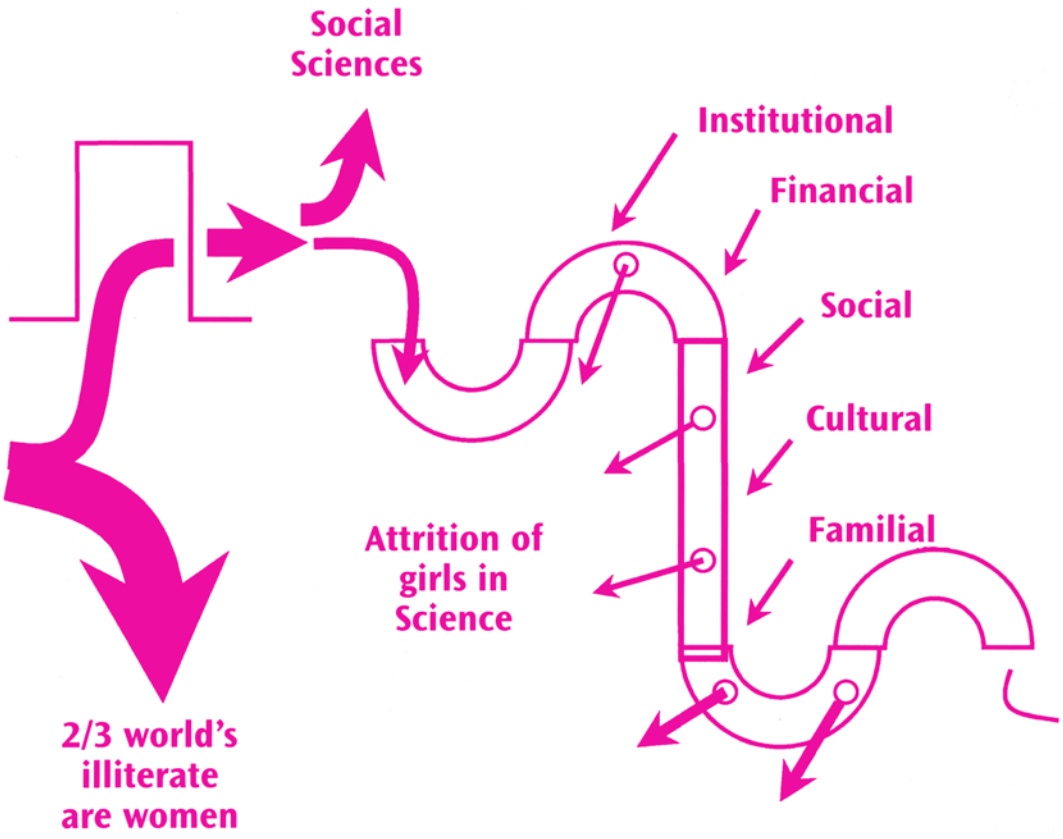
- a commitment from men and women in top positions to attracting women into technical, technological and scientific occupations and to creating women-friendly environments;
- serious attention to heightening awareness of gender equality issues through pertinent and timely education and awareness programmes;
- women involved in the process of change at all levels of education, in the workplace and professional associations;
- co-operation from educators, employers, technicians, technologists, scientists and engineers in order to bring positive change to the image of technical and scientific fields;
- challenging goals within realistic time frames, the incorporation of which should include comprehensive strategies for longer range implementation;
- mechanisms to measure and report on change in the elementary and secondary school system, community colleges and technical institutes, universities, workplaces and professional associations.

The federal government responded in part by creating the Canada Scholarships Programme that reserved 50 per cent of the awards for women.

Of those who do gain access to schools, a smaller proportion of girls than boys obtain training in science and technology. Of those who do enter the sciences, many opt to leave. This phenomenon has sometimes been called 'The Leaky Pipeline' and several factors may contribute to it, including familial and financial pressures, teaching methods, and the lack of links between science and society (see Fig. 4).

Some countries have begun to respond to the fact, shown by research done in Canada, that boys and girls do not respond to science in school in the same way (see Box 7). They often identify distinct problems from the same data, and attempt to solve them differently. Typically, boys dismiss context and select out one aspect of the problem to

Figure 4 **The Leaky Pipeline**



work on while girls value context and take a more holistic approach. Girls also work more co-operatively and are attracted to science that they see as socially relevant. These differences need to be taken into account in curriculum design, which should also reflect the life experiences and interests of girls as well as boys. Studies in Canada and the UK have shown that girls routinely get less attention from teachers and that teachers will often answer girls' questions directly while offering boys information that will allow them to solve the problem themselves (Rathgeber, 1995). Additionally, textbook imaging and vocabulary may be exclusionary, with women barely mentioned in science textbooks and most often shown in illustrations 'as participant observers or as amazed onlookers' (Rathgeber, 1995).

A lack of role models can play a strong role in discouraging girls from pursuing science studies. Biased behaviour by teachers and leaders in school systems can also seriously undermine girls' confidence. Negative stereotyping and a strong pressure against excellence in science because it is 'unfeminine' inhibits and discourages girls, diminishing their self-esteem and reducing their science career aspirations. It also impacts on parents and their role in deciding on their children's education. As noted by the Gender Working Group of the UN Commission on Science and Technology for Development, some parents, teachers and guidance counsellors have the misleading perception that science and mathematics are 'difficult subjects' and not as suitable for girls as for boys. There may also be a parental preference for the education of boys over girls because of cultural reasons and economic constraints, resulting in young girls assuming family and household responsibilities early in their lives. (UNCSTD-Gender Working Group, 1995). Other factors, including teenage pregnancy, may also cause girls to drop out of school.

There is a mutually reinforcing relationship between gender-role stereotyping and access and achievement in the educational system. Yet, when girls are encouraged to study science subjects and targeted for special training, the results can be dramatic (see Box 8).

The sex-disaggregated data now available shows a 'side-streaming' of those girls who do study science and technology towards certain fields and away from others. Males dominate the natural sciences, engineering and agriculture; females are more likely to be found in the social and biological sciences. UNESCO has also found that females generally account for significantly higher percentages of enrolment and training oriented towards commercial and service trades than industrial and engineering trades or occupations (UNESCO, 1995).

Box 8 **Interventions in Gender and Science Education (Commonwealth)**

An understanding of the different ways in which boys and girls respond to science and technology has prompted interventions within some Commonwealth countries:

- In Australia when a pre-university physics course was started that required the learning of physics to be placed in context, including assessment tasks that enabled young people to demonstrate understanding, young girls suddenly became very good at physics.
- An in-service programme for primary teachers, managed from Currin University, Western Australia, developed the teachers' confidence in their own understanding of science (electricity) and their skills in facilitating gender-inclusive learning for their students.
- A Botswana Road Show was developed to visit schools accompanied by local women scientists and technologists to give girls hands-on experience and to demonstrate that women were doing science-related jobs.
- Within an initial training course in Waterloo University, Ontario, Canada, student teachers were encouraged to question the nature of science and to develop their own understanding of topics through personal enquiry. The anger felt by some young women over their earlier experiences of a science education which made them feel so stupid, was palpable.
- In India, based in Ahmedabad, some 60 women scientists have organised themselves to deliver science informally in rural villages. Science and Technology for Women and Children (SATWAC) bases much of its work in the every day experiences of women and on toys that can be made out of discarded materials.
- A project developed within the National Federation of Women's Institutes in the UK, entitled 'Science, You and Everyday Life', has succeeded in breaking down the alienation many women felt from science. The Federation now has a structure of regional and county science co-ordinators to continue the participation of members in science-related activities.

Source: Harding, Jan (2000b)

Girls' lack of access to science and technology education has multiple impacts. It limits their opportunities to meet their basic needs and improve the quality of their lives and those of their families. It also restricts their access to employment and ability to create businesses. The gender gap also deprives nations of the contribution of many highly talented citizens. Education and training are also key to ensuring women are present at the decision-making tables and are able to assume leadership positions. When women are excluded from science and technology in any culture, that culture is

Box 9

Science, Technology and Maths Education (STME) Clinic for Girls (Ghana)

The Science, Technology and Mathematics Education (STME) Clinic was instituted in 1987 to encourage girls to take up science and mathematics subjects, do well in them and stay with them. It brings together approximately 150-200 girls from secondary schools from all over the country and from other African states for a two-week intensive exposure to the scientific environment. The girls interact with female scientists who are brought in as role models and also visit institutions of higher learning in sciences for a better understanding of the various subject areas as well as industries and scientific research institutions to acquaint themselves with the various job opportunities that exist there. After a one-week survey of science and technology fields, the girls select areas of interest and then work alongside mainly women scientists and technologists for about four days to have a feel of working as a scientist.

The STME Clinic also offers in-service and pre-service training for Science and Technology teachers in gender-sensitive teaching methodologies, including how to involve girls in creative and interesting hands-on science and math activities and the use of everyday examples including games and domestic activities with which girls are familiar, to press home scientific facts and concepts. Teaching approaches take into consideration the fact that women, on average, are holistic learners, use co-operative learning styles and tend to prefer group work. In addition, teachers are shown how to recognise language and teacher-student classroom interaction which are gender biased and given tools to correct this. Gender balanced curriculum materials are also promoted.

Within the first five years of the project, there was a 76% increase in the number of girls who opted for science at the secondary level. While the total number of females studying science at the secondary level still remains small, this is a dramatic beginning.

missing half its talent and capability for solving social problems and improving the life of its people (Hays and Farhar, 2000).

Science education in schools has to serve several purposes, including preparing those students who will go on to study science and technology at university and become scientists and engineers and providing all students with a general understanding of the nature of scientific knowledge. In order to facilitate the latter, it has been convincingly argued that science education materials should be redesigned to focus on 'the role of science and technology in societal development and more specifically on [its] usefulness and relevance ... in everyday life rather than on the capacity of man to master machines' (Rathgeber, 1995). This should include an understanding of basic scientific precepts and the ability to apply them to issues of science in society as informed citizens (see Box 10). This can enable them, for example, to make choices about personal issues such as birth control as well as to decide whether a new technology that is being proposed would be harmful or beneficial. The UNESCO Declaration on Science and the Use of Scientific Knowledge and the Science Agenda, which came out of the 1999 UN World Conference, states that: 'Science education, in the broad sense, without discrimination and encompassing all levels and modalities is a fundamental prerequisite for democracy and for ensuring sustainable development' (UNESCO, 1999).

Box 10

Science and Technology Awareness Group (Australia)

Australia's Science and Technology Awareness Group was established in 1989, with the aim of increasing awareness and understanding of the central role which science and technology plays in Australia's economic and social well-being. The ultimate vision for the programme is a nation whose citizens are well-informed about and comfortable in debating science and technology issues, and whose young people are giving due consideration to extending their formal education in science, engineering and technology beyond the compulsory years of schooling. The programme has five target groups: young people and their teachers; women; industry and business leaders; scientists, technologists and engineers; and journalists and other media.

In order to promote its central goal, the Group uses a variety of inter-related activities, deriving from an overall strategy which has short, medium, and long-term objectives. Activities currently include:

- The Australia Prize
- The Michael Daley Awards for science, technology and engineering journalism
- Science, Engineering and Technology Awareness Raising Projects
- Register of Science and Technology Communicators, published biennially
- FACETS quarterly newsletter for science and technology communicators
- National Science Week

Programme strategy involves delivery of a number of activities aimed at raising awareness, focussing on the target groups. It has an annual budget of approximately $3.6 million, of which $1 million is devoted to Awareness Projects grants.

Scientific literacy equips citizens to actively engage in important debates on the role of science in society, including the setting of appropriate limits to science. It includes both indigenous or local scientific knowledge gained through informal sources as well as institutional or formal knowledge. It is about capacity building as well as confidence building, and educational programmes need to be gender-sensitive, inclusive, people-centred and contribute to a more sustainable practice of science and technology.

Recommendations

- Provide the same opportunities for access to formal education for girls as well as boys.
- Ensure literacy and basic instruction in science and technology for both boys and girls.
- Ensure that infrastructure, laboratories and equipment in schools are equally available to girls and boys.
- Ensure that teaching materials in science and technology are sensitive to gender concerns in terms of language and illustrations.
- Ensure a strong link between the science taught and the everyday lives of girls and boys.
- Broaden the teaching of science to include elements addressing the economic, social and ethical implications of science and technology.
- Recognise the importance of women science teachers as mentors and role models and provide rewards to those who devote substantial time to this activity.
- Provide multiple opportunities for re-entering school, especially for young mothers.
- Introduce education programmes with flexible locations and times to enable more students, especially girls, to acquire scientific literacy.

- Introduce new approaches to science and technology education such as distance learning, making optimal use of both old (radio) and new (multimedia) technologies.
- Establish special scholarships for women entering science research and careers.

Science and technology careers and decision-making positions

Many highly skilled women, once launched on science and technology career paths, opt out. An APEC study published by the Human Resource Development Working Group entitled 'What's in a Job? Equity in Human Resource Development in Asia-Pacific Economies' calls for research to understand more fully the reasons behind biased practices in the workforce, including barriers to women created by legislation and regulations.

While the number of women working in traditionally male-dominated fields is increasing, a range of visible and invisible obstacles continues to impede their retention and advancement in non-traditional careers. Strategies to increase the recruitment of women into science and technology careers, while necessary to redress historical imbalances, are insufficient. A supply-side strategy alone will not solve systemic discrimination within institutions. Several important studies have confronted the 'Chilly Climate' in institutions and suggested strategies.

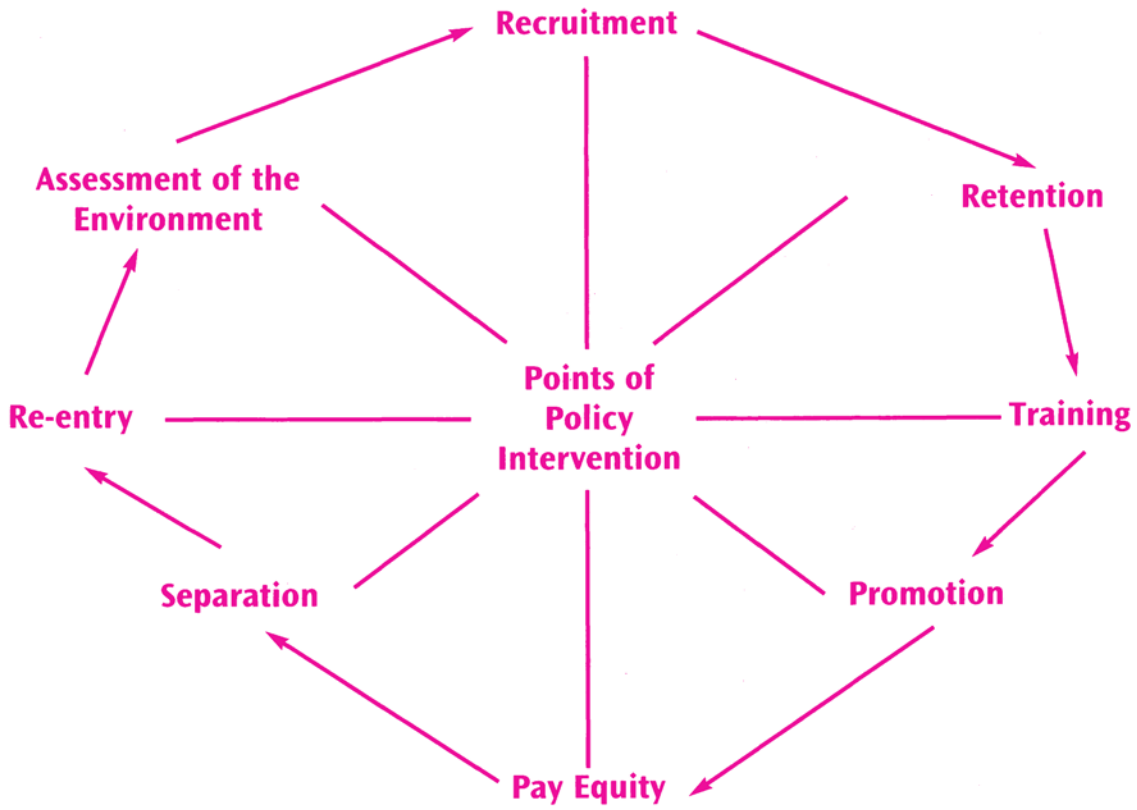
The UNCSTD Gender Working Group identified the removal of obstacles to women in science and technology careers as one of its seven 'Transformative Actions'. The Report set out a series of specific strategies to enhance women's participation, including:

- Alternative work arrangements such as flexible hours, flexible locations and job-sharing, and corporate commitment to on-site child care facilities;
- Maternity and paternity leave policies and promotion criteria to allow for honouring family responsibilities without jeopardising career progression;
- Policies against discrimination and harassment in the workplace;
- Commitment to hiring, promotion and career development of women in science and technology while adhering to the merit principle.

The UNESCO 1996 World Science Report also elaborated a range of policy instruments and innovative strategies to help dismantle discriminatory practices in the workplace. These tools have been designed to create 'Enabling Environments' inside institutions (see Fig. 5 and Chapter 7). Templates and training modules have been designed, corporate policies written and videos produced which can be adapted across companies and countries. Consultants can conduct gender audits on organisations to assist in rendering visible points of discrimination in the system from the time of entry (including entry interviewing) through mainstream corporate policies (sexual harassment, ombudspersons, mentoring, promotion policies, etc.) to the point of exit (severance packages and exit interviews). The competitive imperative to draw on the brightest talent, regardless of gender, has led to the development of increasingly sophisticated tools to evaluate these systemic institutional barriers. Best practices developed to address these barriers constitute a valuable source of case studies and can serve as useful templates.

Historically, men have cultivated and effectively used personal and professional networks. As a result, they have access to well-established routes of influence and career support. Often 'knowing how', the accumulation of technical skills and competency, is a necessary but not sufficient factor in achieving and sustaining success in organisations and careers. 'Knowing who' to turn to for advice, mentoring, role modelling and career development can also be a critical factor (see Box 11). The report of the APEC Working Group on Human Resource Development for Industrial

Figure 5 **Removing Systemic Barriers in the Workplace**



Technology, 'Industrial Technology Training Programmes for Women: Gender Issues and Programme Success Factors', identifies support systems as a key element in overcoming the isolation of girls and women in science and technology and technical and vocational trades.

The Internet offers a myriad of virtual networks for women in science, engineering, and business. Interesting examples include SYSTERS, an international network designed for professional women in computer science; SYSTERS-STUDENTS, a support network for young women studying computers; WISNET for women in science, mathematics and engineering; WITI, a discussion group of women in technology; WNE, a network of women in nuclear science; and WIRED Women for women in IT/Internet-based careers. Other examples of networks are given in Chapter 6.

Recommendations

Institutional barriers precluding an inclusive and enabling environment for women pursuing careers in science and technology should be systematically removed through a series of steps, including:

For the Employer:

- Alternative work arrangements such as flexible hours, flexible locations, and job-sharing opportunities.
- On-site childcare facilities.
- Maternity and paternity leave policies.
- Hiring and promotion criteria and processes allow for family responsibilities to be

Box 11 **Women Inventors as Role Models (Malaysia)**

In August 1992, a women's section of the Malaysian Inventor and Design Society (MINDS) was established, calling itself LADYMINDS. The following year, LADYMINDS established a National Women Inventors Award. The winner of the 1993 award was Dr. Choo Yuen May, who has to her credit 11 patented inventions, most of which are being used commercially.

Dr. Choo used crude palm oil for four of her inventions as palm oil is the richest plant source of carotenes. With her co-researchers, she developed novel processes including the conversion of crude palm oil and palm oil products into methyl esters, which have been successfully demonstrated to be superior oleochemicals, i.e. derived from oils and fats, as well as environmentally friendly and renewable biofuel, i.e. a diesel substitute. Dr. Choo's most recent patented invention, which she developed alone, is a higher yield process for the production of monoglycerides and diglycerides also using palm oil and palm-oil products. This new process provides lower-cost products with better emulsifying properties of higher value, which are in great demand in the food industry.

Other Malaysian women inventors include:
- Asma Ismail, a university associate professor, who co-invented an antigen to detect salmonella typi, the causative agent for typhoid fever;
- Halmahton Hamdan, a university associate professor, who co-invented Zeolite molecular sieves (an important component mainly for the detergent industry) using rice husk ash, a waste produce;
- Liana Low, a businessperson, who perfected the design of an all-plastic solar heater first invented in Australia and concocted palm-based biodegradable skincare products and cosmetics; and
- Lee Yip Fong, an art and design teacher, who invented a multi-safe clothes hanger whose main feature is a hook to prevent the hanger from being blown off the laundry line in strong winds.

assumed so that maternity, paternity and parental leaves do not jeopardise career progression.
- Promotion of women's careers in science and technology while adhering to the merit principle.
- Policies against discrimination and harassment in the workplace.

For Governments:
- Tax relief for payment of child-minders.
- Pay equity legislation.
- Legislation against discrimination.
- Collection of sex-disaggregated statistics.
- Establishment of focal points for advice on gender in science and technology.
- An increase in the number of women appointed to policy advisory and decision-making bodies.
- Seeking input and advice from women's professional science and technology NGOs and include representatives from these groups on government delegations to meetings.
- Establishment of databases of professional women to provide institutions with a pool of names of qualified women to be considered for appointment to policy and advisory bodies.

- Assistance to non-governmental networks of women in science and technology with the design and mounting and maintenance and funding of websites.

For Academic Institutions:

- Establishment and support networks of female professionals in science and engineering.
- Setting up and support mentoring, role-model and career advisory programmes.
- Providing flexible tenure criteria to accommodate family roles and responsibilities.
- Providing refresher courses and re-entry scholarships for women returning to careers in science.
- Establishing 'Chairs on Women in Science and Technology' at Universities to act as focal points for facilitating and mentoring women. Support these Chairs with appropriate resources (see Box 2).

The Differential Impacts of Science and Technology

Science and technology can bring about profound social change, which is likely to impact differently on the lives of women and men. One of the two central conclusions of the UN Commission on Science and Technology for Development (UNCSTD) Gender Report tabled with ECOSOC and at Beijing in 1995 was the gender-specific nature of technical change. It made the point that: 'To ensure that science and technology benefits all members of society, attention must be paid to the respective needs and interests of men and women equitably'. A more socially equitable distribution of benefits can be ensured by utilising three tools to highlight differential impacts: applying gender analysis to policy elaboration; seeking women's input into programme development; and collecting sex-disaggregated data.

The systematic use of gender-based analysis in the elaboration of policies and programmes in science and technology departments renders visible their differential impacts on women and men. It allows decision-makers to tailor programmes where possible, and provide for compensatory measures where needed. For example, technical change may result in significant dislocation of women in the workplace with repercussions of unemployment, under-employment or de-skilling. A 1967 ILO study of employment looked at different employment sectors where machinery was introduced to activities traditionally done by women. In every case, men either completely replaced women or the activity became sub-divided, with men taking over the tasks that used technology and required greater skill and women doing those that were less skilled (Everts, 1998). Similarly, in the agricultural sector of South Africa, women have traditionally sustained the community through their use of appropriate technology. Far from improving their lives, the effect of modernisation and the development of technologies to improve productivity has been to alienate women from these processes (Ofir, 2000).

Gender analysis in science and technology policies and programmes will ensure a stronger science. For example, when clinical trials are undertaken, the faulty practice of extrapolating results from one gender to the other can be avoided. Having women scientists in decision-making positions would undoubtedly lead to the development of different sorts of research priorities and technology. A recent study on women in science and technology provided documentation of how women apply and utilise existing technologies in innovative and people-centred ways. It also revealed how they approach and prioritise activities; provide unique perspectives; transform science and technology; implement international commitments on gender, science and technology; and add value to science and technology in ways that benefit women, the community, the economy and the larger society (Hays and Farhar, 2000).

The Intermediate Technology Group (ITDG) has noted that women have been excluded,

both conceptually and practically, from the development of technology and its transfer (Harding, 2000a). Women, especially the poorest, need access to improved technologies to reduce the drudgery of their work, increase their productivity and in other ways increase their well-being (Carr, 2000). At the same time, they already use technical skills and knowledge in their daily lives and are themselves the best source of information about which technologies would be appropriate to their needs. Meeting these needs is also meeting government's commitments under the Convention on the Elimination of All Forms of Discrimination Against Women, since the CEDAW Committee has asked states to include in their reports information about appropriate technology being used to facilitate women's working and living conditions (5th Session, 1986).

Participatory research methods reveal a range of indigenous knowledge systems and involve local communities in assessing their own technical needs (see Box 12). An innovative project called 'Do It Herself' trained women with no previous experience in research to gather and compile information on women's technical skills and knowledge of food processing, traditional medicine and technologies used in income generating projects such as the processing of coconut fibre (Appleton, 1995). Their knowledge and connections to the community helped them to uncover a range of women's skills in technology that had previously been ignored.

The absence of consistent and comparable data is a major impediment to designing, developing or defending effective policies and programmes. The UN World's Women's Conferences in Mexico (1975), Copenhagen (1980), Nairobi (1985) and Beijing (1995) all repeated the call for co-ordination and consistency at national and international levels in the collection of statistics on women. Despite these repeated

Box 12 **Participatory Research in Action (Trinidad and Tobago)**

Data gathered in this study in Trinidad and Tobago were based on a gendered and interdisciplinary examination of the socio-economic, cultural political and ecological factors affecting the sustainable use of the Nariva Swamp, an ecosystem where new strategies needed to be developed for sustainable livelihoods. The primary goal of the project was to empower the communities, with particular emphasis on the women, and participatory research methodologies were therefore employed. By involving community members in the research process, posing problems, validating their knowledge and generating discussions, it was hoped that they would get the confidence to analyse their situation and come up with effective and sustainable development proposals. In the case of women, it necessitated identifying and acknowledging the sources of their oppression and powerlessness and meeting their strategic needs.

The research team (three females and one male) came from different disciplinary backgrounds: Agriculture, Ecology, Economics and Gender Studies. An important feature of the process was that they lived together close to the community for nine months and held nightly discussions on the data gathered by each during that day. This provided an opportunity for refinement and validation. A facilitators' workshop was held to train twelve community members to conduct Participatory Research (PR) followed by a community workshop at which the trained facilitators shared what they had learned with other community members. A further aspect that facilitated community empowerment was the data giveback session to the community and their participation in the workshops held for academics, stakeholders and policy makers.

Source: Centre for Gender and Development Studies, University of the West Indies, Trinidad and Tobago

calls, there persists a scarcity of sex-disaggregated data in science and technology. The degree of difference between girls and boys in both access to primary school and opportunity for higher education may not be readily apparent where there is no consistent and comparable data. Similarly, the differential impacts of policies and global agreements on the lives of women and men may not be clear. The systematic use of gender analysis and sex-disaggregated data can render visible these differences and permit policy makers to put into place programmes to proactively address and alleviate the differential impacts of technical change.

Recommendations

The Commonwealth Secretariat should:

- Liaise with the Gender Advisory Board (GAB) established by the UNCSTD and with GAB focal points globally that are implementing the Declaration of Intent and seven Transformative Actions on gender in science and technology;
- Convene an international meeting of statisticians, along with science, technology, and gender specialists from national and international bodies to identify the critical statistics necessary for policy purposes; to designate responsibility centres; and to establish mechanisms for co-ordination and collaboration;
- Decide on methods and common approaches to permit cross-cultural comparisons over time and to ensure the best use of resources.

Governments should:

- Ensure the systematic application of gender-based analysis into all science and technology policy and programme activities of the department and affiliated research agencies;
- Promote the implementation of the Transformative Actions through the establishment of national programmes for women in science and technology.
- Revise statistics data-collection methods to ensure sex-disaggregated statistics are systematically and regularly collected both on participation rates and on differential impacts;
- Ensure the collection of complementary sets of data, using common methods across Commonwealth countries;
- Make the data collected available to both local and international bodies to ensure their maximum use in policy and programme formulation and to ensure their aggregation at the regional and international levels.

Biotechnology and Ethical Issues

Issues concerning science and ethics can be divided into the lack of (or need for) ethics frameworks, both within the scientific research enterprise and for government and intergovernmental bodies; and the ethical implications and impacts of science and technology on the lives of women and men in society. The 1996 UNCSTD Gender Report contended that ethical issues associated with both the conduct of scientific research and the application of the results have a gender dimension that has not been sufficiently recognised or addressed. The Report calls on governments to develop ethical codes of conduct to provide clear boundaries of accepted practice in science.

Medical technologies now touch us intimately at every stage of our lives. Technology gives us the unprecedented power to create, manipulate and alter human life in the laboratory; to keep people alive in a state of living death; to use one person's organs and tissues so that another can live; to create clones of ourselves (McTeer, 1999). Our very definition of who we are and what it means to be human is challenged. The essential question has become: How do we balance the ability of science and medicine to enhance our lives with our obligations to protect individual and collective rights? 'We can neither put the genie back into the bottle nor let it go around granting any

old wish. We must give the genie some rules' (Kennedy, 1991).

Many implications of these fast emerging technologies have particular impact on vulnerable populations including women. Ethical issues arising out of the applications of science and technology in society that especially have a bearing on the health and rights of women include: abortion issues, embryo experimentation, cloning, surrogacy, genetic engineering, sex predetermination and becoming subjects in human experimentation. In the context of the new reproductive technologies, for instance, women should be encouraged to be critical of so-called miracle advances and developments and to become more involved in crucial decisions about their bodies and lives.

In 'Setting Boundaries, Enhancing Health', the Canadian Royal Commission on New Reproductive and Genetic Technologies (NRGTs) stated that government reproductive policy should not proceed as though reproduction affects women and men in the same way: 'The physical and social burdens and risks of reproduction are borne primarily by women. These realities should be acknowledged and reflected in reproductive policy. The rights of children born as a result of NRGTs must also be considered when equality issues are examined'.

In the reproductive field and in others, women's studies have shown that the practice of science reinforces sexist, racist, homophobic and class biases, which have become part of the metaphysics of science. Within science, the predominantly male conception of women's nature has caused women to be excluded from the very process of defining themselves. When included, women have been made the object of study. This has meant that women's participation in the definition of science, its ethics, direction and social implications has also been precluded.

Similarly, studies during the last twenty years that have focused on the ideologies, politics, epistemologies and economics of science have shown that the values discourse concerning science (ethics and justice, for example) has yet to take on board the multiplicity of women's experiences and views of the social construction and conception of science. This scholarship asks for a recognition of the ways in which values actually inform the practice and theory of science. From the social structure of the laboratory to the ideology of women's nature, to the gender bias of scientific language, feminist writers and others in science point out the political context and role of contemporary science. Science must be made accessible to more people and the process of its validation should be under greater public scrutiny.

There is a need to acknowledge that science is a human social activity and it is a fallacy to think that because the scientific method is objective, then scientists' objectivity is also guaranteed. There are also examples of misconduct amongst scientists, including falsification (misrepresentation of results), fabrication (of experiments never performed) and plagiarism. In the case of plagiarism, the available data show that women are more susceptible than men to their work being unacknowledged or 'taken over' because they are usually lower in the hierarchy of the scientific enterprise.

Recommendations

Governments should:

- Support and develop conventions, declarations and codes of ethics to provide clear boundaries of acceptable practice in research and in application of science and technology giving specific attention to their differential impacts on the lives of women and men and vulnerable populations;
- Provide regulatory departments, which traditionally have approved products based on a science-based risk assessment, additional tools to incorporate an analysis of the ethical dimension of technologies and the resources to undertake citizen engagement;

- Ensure that science and technology departments hire professionals trained in ethics, including feminist ethics and fields emphasising science in society, in order to provide additional needed input into the science-based risk assessment process;
- Ensure that government-supported research agencies dedicate a portion of their funding to the consideration of the ethical, legal and social issues (ELSI) including systematic gender-based analysis and that all research is guided by research ethics boards (REBs);
- Provide departmental decision-makers with expertise on gender in science and technology to ensure that feminist bioethics and feminist ethics are articulated;
- Promote the systematic introduction of ethics into the teaching of science in schools at all levels of education including technical colleges and universities.

NGOs and associations of women is science should:

- Play a role in articulating the views of women concerning issues of ethics and science;
- Enlarge their networks and act as fora that highlight the special concern of women and women's perspectives, as well as the role that women have and can play in the development of science and its social and ethical implications.

Information and Communication Technologies (ICTs)

The recent technological revolution, centred around the rapid growth and spread of Information and Communications Technologies (ICTs), has been reshaping the material basis of society, as well as bringing about a profound restructuring of economic, political and cultural relations among states (Marcelle, 2000). Indeed the present phase of globalisation and economic liberalisation is very much driven by ICTs, mainly controlled and dominated by multi-national corporations located in the industrialised countries. It would not be an exaggeration to say that, with the global economy increasingly organised around information flows, control of – or at least access to – ICTs is key in competing for a share of the market, with implications for the international division of labour.

While the growth and expansion of the global ICT sector can contribute to human development through their effects on economic, social and political structures and processes, they are not necessarily aligned with the needs of developing countries or women. Discourse on ICTs, gender and globalisation has to be located within the following contexts: an understanding of the forces and interests driving the creation and expansion of ICTs; an examination of the organisational structure and institutional arrangements which facilitate the application of ICTs, particularly in terms of its costs and benefits; and an analysis of the impact of ICTs on social and gender relations at various levels and sectors in society, such as the home, work and society.

The Internet has emerged as an important medium of information and commercial flows today. The majority of the users, however, are in the developed countries. Even though Internet usage is accelerating in developing countries, this is predominantly among the urban elite and, particularly in the poorest countries, ICTs will be an exotic and inaccessible commodity for most people well into the next century (Mansell and Wehn, 1998). An inadequate infrastructure and a lack of resources and the requisite expertise means that 'out of 5.7 billion people, at least 5.6 billion are excluded from the so-called wired or network society' (Mitter, 1998).

Enormous disparities in terms of access to the National Information Infrastructure (NII), a necessary precondition for IT application, are reflected among Commonwealth countries. In 1995 the teledensity (telephone lines per 100 people) in Canada and Australia was 59 and 51 respectively, compared to 0.4 in Ghana and 1 in Papua New Guinea. Internet users per 1,000 people were 41 and 55 in Canada and Australia in

contrast to 0.2 in Solomon Islands and 2.0 in Malaysia. Likewise, the personal computer ratio discloses the immense gap in ownership in terms of the highest (223 per 1,000 in New Zealand) and lowest (0.7 per 1,000 in Kenya) (UNDP Human Development Report, 1998).

Not only is there a wide NII gap between countries, but the principle of universal access is denied within the countries themselves. There is a gender gap between the information 'haves' and the 'have-nots'; the latter are usually the rural poor and women. With women forming the majority of the world's 1.3 billion poor, and owning only 1 per cent of the world's land, their opportunities to access, let alone control ICTs are almost non-existent. In addition, in the last 20 years, the number of rural women living in poverty has increased by 50 per cent, compared to 3 per cent for men, leading to the declaration that 'poverty has a female face' (Wee, 1995b). Women in developing countries thus have to overcome a double burden of marginalisation. A study conducted in 1997 by the Women in Global Science and Technology (WIGSAT) on African women's access to and use of ICTs revealed the gendered nature of the systems within which women seek to meet their information and communication needs. Another study, quoted by the Association for Progressive Communications (APC), claims that male domination of computer networks is as high as 95 per cent (APC Women's Programme, 1997).

The gender biases that limit women's access to science and technology training also result in women's under-representation in high status positions within ICT firms (Marcelle, 2000). At the same time, ICTs have an enormous impact on employment and work, with attendant implications for social and gender equality. The introduction of ICTs leads to a fragmentation of the labour process in manufacturing: low-skilled and repetitive work on the one hand; and an upgrading of workers' high-grade skills in multi-task jobs using ICTs on the other. There is a growth of white-collar jobs in the service sectors, the majority of which are fast utilising ICTs. Some of these positions are filled by young graduate women with the requisite IT and business management skills and training. As a result, there is a growing polarisation of labour between men and women and among women possessing high and low technological skills. In addition to class and gender, age will also be a differentiating factor in the information society, as elderly women and men in the workforce, unless they are provided the relevant training, will find their skills outmoded and unmarketable.

Facilitated by ICTs, restructuring and downsizing are taking place simultaneously with labour flexibility as companies, both local and international, compete in the global economy. This has caused a shift to a combination of regular work with various forms of non-regular, flexible employment which can be undertaken through relocation outside the city centre or to low-wage countries. The core workers in the firm are technologically skilled men and women. The emerging part-timers and sub-contracted workers are mainly women from urban and rural poor communities, or are migrant workers who are low-skilled, low paid and are not protected by existing labour laws. The use of non-regular workers weakens the ability of workers to organise themselves, as well as the ability of unions to organise what falls under the 'informal sector'. The value of women's work, particularly in the industrial sector, is still perceived as inferior and secondary to men's work and is thus not rewarded despite technological changes and increased productivity.

Many countries do not have institutional and policy initiatives to deal with the negative effects of the transition from low-skilled to capital-intensive and high technology industries. Even when new forms of information-intensive work are being introduced, such as teleworking and teletrade, the benefits to women are uneven. Telehomeworking for women might increase their productive and reproductive

load rather than enhancing their quality of life through the combination of work and home. It is often men, as highly skilled professionals, who benefit from telehomeworking, as the gender division of labour spares them the burden of reproductive labour.

Participation in decision-making in production and regulation of the ICT sector is limited. The few groups that do represent the interests of gender equality and sustainable human development are marginalised, occupy low status and are seen to have little legitimacy (Marcelle, 2000). Women employees are usually not consulted when new technologies are introduced in the factory or office floor. It is only in the smaller firms which are ICT intensive, such as software firms, that some form of fluid management practices occur and there is employee participation and co-operation.

New occupational health hazards have been introduced with the advent of ICTs. These include repetitive stress injuries (RSI) and other problems related to work on video display terminals. Women's reproductive health will also be made more vulnerable. With increased competition under the current trade liberalisation regime, workers have been required to push up their productivity, increasing their labour intensity under the gaze and surveillance of the computer which monitors key-strokes and telephone conversations.

Despite the rhetoric of technical and development co-operation, little technology transfer is taking place from the developed to the developing countries. Under the World Trade Organisation agreement on Trade-Related Intellectual Property Rights (TRIPS), firms would have to pay more for technology rights and patents. Software programmes, usually originating from the West, are notoriously exorbitant for those in developing countries. Women who are starting their own businesses do not have the means to access these new technologies.

Participants at a recent international conference hosted by the UN Economic Commission for Africa, *African Women and Economic Development: Investing in Our Future* (Addis Ababa, 28 April–1 May 1998), looked at the gender dimensions of the impact of ICTs in Africa. A debate arose as to whether computers would be useful or an irrelevance to women who had no access to basic amenities such as water. The answer of many of those present was that computers might be the best means of providing women with up-to-date information in a number of different areas, including appropriate technology and markets for the goods they produce. At the same time, participants agreed that it is not enough for women to be simply passive participants in the development and dissemination of ICTs; they must also be decision-makers and actors (Rathgeber and Ofwona Adera, 2000).

Some progress has already been made by NGOs in using ICTs as a tool for furthering women's empowerment, 'to expand their access to information sources, improve the effectiveness of their lobbying, widen the reach of their information dissemination activities and increase the extent to which they are internationally integrated' (Marcelle, 2000; see Box 13). In the field of women's human rights in particular, activists are using computers and electronic communications as tools that are fast becoming an integral part of local and global strategies to demand, protect and defend those rights (IWTC, 1998). At the same time, in addition to using ICTs as tools for achieving practical and strategic objectives, it is important for the gender and development community to become more active in putting forward a critique of the whole area of ICTs and development. Most important, though, is a recognition that strong and effective government leadership is essential for mainstreaming gender considerations into national ICT policy and implementation.

Box 13

Women'sNet (South Africa)

The primary aim of Women'sNet is to enhance the ability of both law and policy makers and civil society to impact on various political and decision-making processes that seek to redress the unequal status of women in South African society. Its development was facilitated by the Southern Africa Non-governmental Organisation Network (SANGONet), which focuses on integrating the provision of an accessible and affordable electronic communications infrastructure with training and other capacity building activity, including the provision of useful information. From the outset, SANGONet earmarked gender and women's issues as a critical area for information development and linking of organisations. SANGONet has worked with its international partner organisation, APC, to provide hundreds of women with technical skills training.

Women's Net has developed into a sophisticated structure that links people and organisations related to gender as well as science and technological issues. Currently, it is involved in a number of projects such as:

- posting new documents and information related to gender equality
- monitoring of gender events in government
- a national events calendar
- participatory policy for UMS
- directory information
- links to relevant sites
- feedback feature
- electronic conferences and mailing lists that are sector-specific

This emphasis on interactive or participatory communication has meant that technology is not left to tell its own story. Definitions and contextual commentary help locate the information. A multimedia approach also ensures that the information circulated by Women'sNet can reach broader communications networks.

www.womensnet.org.za/

Recommendations

- Establish a gender audit team at the Commonwealth level to study the impact of ICTs, and globalisation;
- Undertake regular technology assessments to evaluate the social, economic and health implications for both women and men;
- Network with other like-minded organisations to ensure that the present phase of globalisation and ICT innovations benefit the majority of the people and not just the elite;
- Ensure that ICT-poor countries have access to these technologies; for example debt-laden countries to utilise such payments for the development of ICT infrastructure which should have universal access as its first principle/condition;
- Establish genuine attempts at technology transfer and/or the creation of technology from developed Commonwealth countries to their developing counterparts;
- Set up a regulatory framework(s) to govern ICT flows and applications which would benefit all countries in the Commonwealth;
- Establish schools and/or telecentres which serve the community, especially the marginalised, as well as provide multi-function activities, e.g. ICT training, income generating activities;
- Establish special schemes to those made redundant as a result of technological change/restructuring, especially women who find job re-entry more difficult;

- Produce software that is user-friendly to meet the information requirements of women in nutrition, health care and education;
- Form websites in local languages and with local content that will benefit non-elite women;
- Find alternative ways of achieving cost-effective connectivity, especially for women in poor and rural communities;
- Encourage and facilitate the participation of civil society, including women, in the formulation and implementation of ICT policies and development programmes;
- Recognise and reward new inter-active and communication skills which have emerged as a result of the introduction of ICTs;
- Provide information and formulate internationally recognised standards on health and safety hazards relating to ICTs;
- Set up technology agreements between workers' representatives/unions and management as well as company codes of conduct/best practices related to technological change.

Habitat Development

Mainstreaming gender into the science and technology of habitat development implies not only involving women alongside men in order to make shelter strategies more effective and efficient, but transforming the whole process of human settlements development itself, through a sex-disaggregated, people-centred approach (UNCHS, 1996). Both women and men need to be consulted in the formulation of urban policy and the planning and management of settlements. It is also important to take into consideration that gender intersects with other social relations, including those based on class, race, ethnicity and age.

Current trends in industrialised town planning and modern housing transform and often subvert traditional cultures and household economies, with tragic results for women. Particularly in dense cities in developing countries, more and more women are forced to raise families in substandard high-rise apartment blocks which have been designed for nuclear families, are hemmed in by traffic and pollution, and provide little or no space for self-employment, child care facilities and communal activities.

In many parts of the world, traditional communities consist of household economies, culturally dynamic and ecologically sustainable. The word 'economy' stems from Greek roots: 'oikos nomos', which originally meant 'management of the household'. In many peri-urban and rural societies, women still manage a household that includes not only raising children and performing domestic routines, but also food production in terms of farming and raising livestock and also some kind of home-based business which contributes to the family income. In the urbanising world, habitat-making has lost its communal dimension.

In transforming traditional landscapes, modern town planning has systematically thwarted women's opportunities for creative self-employment, flexible hours, and working at home or close to the children – at best, reducing such jobs to the realm of the 'informal sector'. Women are disproportionately represented among the working poor where they occupy the most poorly paid and insecure jobs. Owing to a misconception that the household consists of a nuclear family, within which the man is the 'breadwinner' doing productive work outside the home while the woman is responsible for reproductive and domestic work, shelter polices have failed to take women's specific needs into account (N'Dow, 1995). The notion that 'men create habitats, women live and reproduce within them' prevails.

Modern urban habitats are developed by the predominantly male-owned and operated

construction, transport, infrastructure and finance sectors. By compartmentalising the realms of economic production, social reproduction, consumption and recreation, modern land use planning has failed to respond to gender-distinct needs. Women have little or no input into the planning of their neighbourhoods. Their key role as the main providers of basic services in poor settlements and as builders and maintainers of shelter and infrastructure remains largely unrecognised. Furthermore, while urban development could have provided innovative opportunities for women to increase social status and ownership, the converse has often happened.

Women are seriously underrepresented in policy- and decision-making when it comes to planning settlements and designing housing programmes. Yet, in many countries the number of female-headed urban households is growing. For single adult households and lone parent families, predominantly headed by women, low income, poor skills and lack of confidence militates strongly against home ownership or security of tenure or occupancy. Female-headed families are over represented in informal settlements in the developing world, and in the rental market in the industrialised countries (UNCHS, 1996). Limited access to and control over land and housing means the lack not only of the security provided by a place to live and grow but also of access to economic benefits, for example the collateral necessary to obtain loans.

Adopting a gender integrated approach to habitat development means meeting both women's practical needs (e.g. water, sanitation) as well as their strategic needs (e.g. greater participation in urban planning). It also seeks to ensure that both women and men have equal access to and control over resources and opportunities. For example, present transport trends increase mobility for car or motorcycle users – usually the prerogative of men – but result in unsafe streets, poor public transport and declining mobility for everyone else. Women's and men's travel needs differ, and women face problems because transport systems are usually designed around the man's journey to work and because transport planning is concerned with mobility rather than accessibility (UNCHS, 1996). A highway cutting through a town means that women on one side may take twice as long to get to the market as those on the other side.

Women play a primary role in cultural transmission, from breast feeding to education to socialisation into adulthood. An African saying, 'It takes a village to raise a child', sums up the crucial supporting part played by the extended family and community. The low-cost solution to modern housing forces women to raise children and perform housework in high-rise cubicles without this community support. Both at home and at the workplace, women's work becomes more alienating. The industrial workplace, where women make up the bulk of production operators, is a place without children. Women at work worry about the children they left at home. In the home, the communal kitchen has been reduced to a modern workbench lined with time-saving machines. Gender-sensitive habitat development can factor for spaces where the extended family can provide that nourishing role envisaged in the African adage.

Recommendations

- Meet government's commitment under Article 46 of the Habitat Agreement to the goal of gender equality in human settlements development. This includes collecting, analysing and disseminating sex-disaggregated data, including statistically making visible the unremunerated work of women; designing and implementing environmentally sound and sustainable resource management and development; integrating gender perspectives in related legislation, policies and programmes; and promoting the full and equal participation of women in human settlements planning and decision making.
- Activate and institutionalise a process of popular participation at local government level to get feedback from women on family and community needs with regard to

housing design, neighbourhood planning, elderly and child care, health care, public safety, transport and urban environment.
- Introduce an affirmative action policy to increase women's representation at local government level and in ministries of housing and local government.
- Promote a network of women environmental managers, social scientists, urban planners, architects, engineers, industrial designers, health care professionals, IT professionals, women entrepreneurs and women in urban governance to forge people-friendly approaches to modern development.
- Provide incentives for pilot projects which design consciously for women, children and sustainable community.

Natural and Human-Created Disasters

'Programmes and infrastructures that are gender-sensitive are needed in order to effectively respond to disaster and emergency situations that threaten the environment, livelihood security, as well as the management of the basic requirements of daily life.'

United Nations, 2000

Women and men experience disaster, dislocation and social conflict in different ways. When human-created or natural disasters occur, it is women and children who are dislodged and suffer disproportionately. Eighty per cent of refugees around the world are women and their dependants. However, even though women are particularly vulnerable, they can also be extremely resilient as reproducers and – in their role as community managers – crucial in periods of reconstruction. During and after war and disasters, women represent an important potential force for the reconstruction of the social fabric of life in these societies, and they play a constructive part in mediation and reconciliation, particularly at the community level.

Armed conflicts, investment in arms technologies at the expense of health, education and social programmes and the infliction of environmental damage impact differently on women and men. In countries where precious national resources are drained off into military science and technology, the brunt of the removal of critical social programmes and safety nets is borne disproportionately by women. Furthermore, most recent and on-going conflicts are civil wars that make the entire country a war zone and cause a major increase in the number of civilian casualties (from around five per cent in the First World War to 90 per cent currently). When war occurs, it affects most heavily those who, by their assigned social role, provide these social safety nets to society when governments fail to deliver: women.

The world now has 26 million people in the regular armed forces; another 40 million in military service, and a stockpile of 51 thousand nuclear weapons. The Gender and Science and Technology Association (GASAT), India chapter, has examined the gender dimension of nuclear disasters. Other scholars have considered the gender dimension of land mines and the war industry on the lives of women and children.

Natural disasters also inflict a heavy toll on certain societies. Each year more than 130 million people are affected by natural hazards such as floods, earthquakes, droughts and cyclones and the destruction caused by natural disasters increases. Between 1971 and 1995, about 99 per cent of people affected (and 97 per cent of deaths) were in developing countries (Twigg, 1997). Disasters are usually dealt with from a purely humanitarian angle, while natural hazards such as cyclones, droughts and earthquakes have been analysed 'technically and scientifically' within scientific disciplines. An alternative approach that has been suggested to deal with disasters sees mitigation and preparedness as the keys to reducing impact (Ariyabandu, 1999). In this approach, all stakeholders – development planners, donors, researchers, practitioners, and communities – have a role to play. Women are key stakeholders, and their participation

Box 14

The Nuclear Threat and Women's Advocacy Role (Pacific)

Women activists in environment and sustainable livelihood issues in the South Pacific region have formed two regional science and technology-based women's collectives: WAINIMATE, the traditional medicine group, and ECOWOMAN, which is the focal point in the region for OFAN, the Once and Future Action Network, linking women in science and technology around the world. Both WAINIMATE and ECOWOMAN are working to link professional women scientists and technologists and grassroots women who practice science and technology. In some cases they are concerned with preservation of the ecosystems on which they depend for their livelihoods; in others they are collaborating to sustainably use their bioregions for economic activities.

Issues of concern and advocacy by women's NGOs in the region go back some years to women's vigorous protests against French nuclear testing in the region, and now to an ongoing campaign to alleviate climate change and global warming. While France has ceased nuclear tests in the region, there is a considerable body of scientific opinion that expects future impacts to be of concern, both in physical damage to the area and medical effects on the populations. The US nuclear testing in Micronesia 40 years ago is a yardstick by which these threats can be measured. Furthermore, when shipments of high-level plutonium travel from reactors in France to the enrichment plants in Japan, it is next to impossible to avoid the waters of French Polynesia, Vanuatu, PNG or the Solomon Islands (they are banned from the Singapore Straits and the Panama Canal). As citizens of the Pacific, women in science and technology NGOs are expressing their opposition.

is needed in the planning, design and monitoring of relief operations, as well as in negotiations with donors. 'The "bottom line" must be to include women at every level and stage' (Walker, 1996).

Governments have increasingly recognised the importance of including a gender perspective in tackling disasters. They recognise the inefficiencies and inadequacies of the existing intervention methods, which fail to take into account the fact that 'women, more often than men, are burdened with the responsibility of meeting the immediate daily needs of their families. This situation has raised awareness that a gender perspective must be incorporated whenever disaster prevention, mitigation and recovery strategies are being developed and implemented' (United Nations, 2000).

Part of viewing disasters through a gendered lens includes seeing women not as passive victims, but as survivors and innovators whose strength and determination help safeguard their communities and families. Women's and men's different needs, interests, vulnerabilities, capacities and coping strategies need to be recognised. For example, a focus on and an analysis of the gender relations and social norms of different societies and communities is essential for the understanding of survival mechanisms and the development of viable disaster management and disaster mitigation processes. In disaster situations, both women and men are disempowered, and relief workers have to be careful not to further erode their positions. Women are traditionally responsible for the management of the home, food, water and family health. Relief programmes which register only men as heads of households, or fail to take into account that women generally have dependants, may put women under pressure to, for example, provide sex in return for entitlements (Walker, 1996). It is also important to take into account the location of water points, the sites where shelters are constructed and the safety of public spaces for women.

Recommendations

- Ensure representation of at least one-third women on all national security bodies and all international security bodies including NATO and the Warsaw Pact;
- Include women's units in the UN Expeditionary Forces and National Disaster Management Teams;
- Set up special UN women's peace brigades for dealing with civil violence and disasters;
- Enable women's encampments at all international borders where violent combat is threatened, consisting of women trained in non-violence.;
- Train and utilise travelling teams of women mediators;
- Offer special recruitment and support for women to study international affairs and conflict resolution/mediation with scholarship support.