SCIENCE, RESEARCH, KNOWLEDGE AND CAPACITY BUILDING

Alfred W. Strigl

Austrian Institute for Sustainable Development, c/o University of Natural Ressources and Applied Life Sciences,Vienna Lindengasse 2/12, A-1070 Vienna, Austria
(e-mail: alfred.strigl@boku.ac.at, www.boku.ac.at/oin)

Abstract. A small part of the scientific community is seeking hard to enhance the contribution of science, knowledge and capacity building to environmentally sustainable and socially fair human development around the world. Many researchers over the globe share the same commitment - anchored in concerns for the human condition: They believe that science and research can and have influenced sustainability. Therefore their main goals are to seek and build up knowledge, know-how and capacity that might help to feed, nurture, house, educate and employ the world's growing human population while conserving its basic life support systems and biodiversity. They undertake projects, that are essentially integrative, and they try to connect the natural, social and engineering sciences, environment and development of communities, multiple stakeholders, geographic and temporal scales. More generally, scientists engaged in sustainable development are bridging the worlds of knowledge and action. This pro-active, heavily ethics- and-wisdom-based "science for sustainability" can be seen as the conclusion of all dialogues and discussions amongst scientists at the World Summit on Sustainable Development (WSSD) 2002 in Johannesburg. The "Plan of Implementation" after WSSD will be based on political will, practical steps and partnerships with time-bound actions. Several "means of implementation" are going to be proofed and initiated: finance, trade, transfer of environmentally sound technology, and, last but not least, science and capacity building.
Some characteristics of working scientific sustainability initiatives are that they are regional, place-based and solution-oriented. They are focusing at intermediate scales where multiple stresses intersect, where complexity is manageable, where integration is possible, where innovation happens, and where significant transitions toward sustainability can start bottom-up. And they have a fundamental character, addressing the unity of the nature-society system, asking how that interactive system is evolving and how it can be consciously, if imperfectly, steered through the reflective mobilization and application of appropriate knowledge and know-how. The aims of such sustainability-building initiatives conducted by researchers are: First to make significant progress toward expanding and deepening the research agenda of science and knowledge-building for sustainability; secondly to strengthen the infrastructure and capacity for conducting and applying science, research and technology for sustainability - everywhere in the world where it is needed; and thirdly, to connect science, policy and decision-making more effectively in pursuit of a faster transition towards real sustainable development. The overall characteristic is, that sustainability initiatives are mainly open-ended networks and dialogues for the better future. A world society that tries to turn towards sustainable development has to work hard to refine their clumsy technologies, in "earthing" their responsibility to all creatures and resources, in establishing democratic systems in peace and by heeding human rights, in building up global solidarity through all mankind and in commit themselves to a better life for the next generations.

Key words: science, knowledge, capacity-building, implementation, sustainable development

To what avail are all our pieces of knowledge,
if we do not care about what holds them together. Dalai Lama

1. Introduction: what does a fair world mean in respect to finite environmental resources?

For several years the concept of "Sustainable Development" has occupied a major role on the global agenda. But although the idea spread over the world, concrete results so far are poor. The World Summit on Sustainable Development (WSSD) in Johannesburg 2002 reflected and reassessed this ambitious goal again. And at this occasion, the international community once addressed the challenges posed by chronic poverty and resource-hungry affluence. Socially just and ecologically embedded development is high on the agenda for the coming decades. This can be fully understood, given the systematic neglect of justice, equity and fairness in world politics. But in contrast to that, the scientists in Johannesburg argued that it was about time that the South along with economies in transition embraced the environmental challenge. They claimed that responsible care for the environment is one of the keys for ensuring livelihood and health for the marginalized sections of the world's citizenry. In fact, many studies and observations show that there can be no poverty eradication without saving the ecological function of nature. In this respect a prominent overview is given in the UNFPA-Report *"The State of the World Population 2001: Population and Environmental Change"*. Moreover, an environmental strategy is indispensable for moving beyond the hegemonic shadow of the North. And both North and South have to leapfrog beyond fossil-based development patterns.

Sustainability at all scales is now historically the greatest challenge. In particular, economic globalization has largely washed away gains made on the micro level, spreading an exploitative economy across the globe and exposing natural resources in the South and in Russia to the pull of the world market. For the Johannesburg Agenda several background themes have been identified which ought to run through all the debates: water, energy, health, agriculture, and biodiversity. Above all, the following question was seen as crucial: What does a fair world mean in respect to finite environmental resources? The answer sounds easy and wise: Real fairness, on the one hand, that entails enlarging the rights of the poor to their own habitats. And on the other hand, it calls for a fair economic and financial system to cut back the claims of the rich to the resources exploited in the South.

The question of global fairness has much to do with life-patterns of the rich population in the North which are spreading out globally. Interests of local communities in maintaining their livelihoods often collide with the interests of urban classes and corporations in expanding consumption and profits. These resource conflicts will not be eased unless the economically well-off around the globe move towards resource-productive patterns of production and consumption. Sustainable production and consumption therefore inherently means fair and many times more resource-efficient technologies and life-styles. The greatest necessity is to achieve sustainable societies through decoupling economic growth and environmental impact. Addressing issues related to clean technology, zero emission or eco-efficiency it is possible, as a point of departure, to generate sustainable energy and material use.

Secondly sustainability needs fair prices and a fair financial system. Due to the burden of debt, the South has to pay interest several times higher than what it gets from official development aid (ODA). The winners of globalization are mainly found in the transnational corporations and financial business sector located in the North. The institutional protagonists for this kind of economic and financial globalization, the IMF (International Monetary Fund), the World Bank and the WTO (World Trade Organization) are heavily criticized for their liberalization policies and blamed for widening the gap between world's poor and rich citizens. We all should be aware that these organizations are ruled and controlled by us – the rich people's nations like the EU-states and the USA. Therefore the key for sustaining world's development is in our politician's hands (Strigl, 2001).

2. Which grand challenges do earth's societies face?

The United Nation Secretary General Kofi Annan reflected a growing consensus towards worldwide sustainable development when he wrote in his Millennium Report *"We, the Peoples: The Role of the United Nations in the 21st Century"* to the General Assembly that freedom from want, freedom from fear, and the freedom of future generations to sustain their lives on this planet are the three grand challenges facing the international community at the dawn of the 21st century (Annan, 2000). But there is great asymmetry in the resources and attention devoted to harnessing science and capacity-building in the service of these three goals.

Efforts to achieve "freedom from want" have created and been supported by several effective research and development systems, for example those engaged in international agricultural research and in certain global disease campaigns. Efforts to achieve "freedom from fear" are supported by a mature, well-funded and problem-driven research and development system for instance in the world's military establishments. In contrast, efforts to achieve sustainability are relatively new because, in the words of the Secretary General, the "founders of the UN could not imagine that we would be capable of threatening the very foundations for our existence." (Annan, 2000) Science, research, knowledge and capacity-building are increasingly recognised to be central to the Secretary General Annan's three challenges (United Nations Development Programme, 2001; World Bank, 1998). The WSSD represented the best opportunity in a decade to construct a global research and development system tailored to the particular needs and magnitude of the sustainability challenge (Sachs, 2000).

The WSSD conference in South Africa was conceived as a follow-up to the Earth Summit held in Rio de Janeiro 1992. But this time, delegates were encouraged to move beyond the environmental focus of Rio, and address the three pillars of sustainable development. The six billion people currently living on Earth are thought to consume 40% of the terrestrial biomass, between a quarter and a third of marine resources and about 50% of the planet's accessible fresh water (UNFPA, 2001). The *"Global Environment Outlook 3"* report from the United Nations Environment Programme warned that half of the world's population is likely to suffer water shortages by 2032 (UNEP, 2002). Yet the global population is projected to climb throughout this century, stabilising at at least 9 billion by 2100 (UNDP, 2001). Mankind's trajectory is far from reaching sustainability. From a scientific point of view we can say: We are most definitely destroying many important ecosystems of the planet.

Mankind still has a long way to go in tackling this challenge. Many times in history, it was a tiny but tenacious minority of committed people (amongst them often scientists - like in the 1970s the Club of Rome) who first defined the misery and have done much to address it (Clark, 1986). Researchers put climate change and the Earth's finite resources on the political agenda (at Rio), and their voices were some of the loudest in calling for policies to be changed in response to these threats. Since the Earth Summit in Rio 1992 these researchers have been more closely in tune with both the public and policy-makers and have begun to coordinate themselves in order to pursue sustainable development in many more arenas. Yet there remains much more that individual researchers and their institutions can do. In this respect this article gives some suggestions.

Gripping the opportunity of the Johannesburg summit will require a strategic approach that has often exceeded the interests of individual nations, policy initiatives and research programmes. Fortunately, important elements of the foundation for such a strategy have been laid out over the last several years through a rapidly expanding discourse on the relationships among science, knowledge and sustainability. Many of the earliest and most thoughtful contributions to this discourse have come from the developing world through the work of individual scholars and institutions such as the International Council for Science (ICSU), the Third World Network of Scientific Organizations (TWNSO), the Third World Academy of Sciences (TWAS) the Commission on Science and Technology for Sustainable Development in the South (COMSATS), the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI), and the South Center (see listed homepages).

European ideas and strategies of the late 1990s are exemplified in Schellnhuber and Wenzel's *Earth systems analysis: Integrating science for sustainability* (1998) and the European Union's Fifth Framework Programme (European Commission, 1998). A synthesis of US views from the same period is given in the National Research Council's *Our common journey: A transition toward sustainability* (1999). Initial efforts to capture an international cross-section of perspectives include the special issue on Sustainability Science published by the International Journal of Sustainable Development (1999), and the World Academies of Science report on a Transition to Sustainability in the 21st Century (2000).

In addition, international environmental assessments are increasingly reaching out to connect with sustainability issues, as are research planning efforts for global environmental change programmes at both national and international levels (Watson *et al.*, 1998; IPCC 2001; United Nations Environmental Programme, 2002. A number of academies of science have also recently addressed the links between sustainability and global change (Rocha-Miranda, 2000; African Academy of Sciences, 1999; German Advisory Council on Global Change (WGBU), 1997; Kates et al., 2000). A great deal of work in the area of science for sustainable development in a WSSD context has been done by the "International Council of Science" (ICSU) which launched a series of ten brochures for Johannesburg. In particular the report 4 (*Science, Traditional Knowledge and Sustainable Development*), report 5 (*Science, Education and Capacity Building*) and report 9 (*Science and Technology for Sustainable Development*) can be addressed here. ICSU is still very active in the post-WSSD process.

3. Was the WSSD in Johannesburg a science summit?

Why is this question raised, when the answer is obviously no? Because it could have been also a science summit - much as it was somehow an NGO-summit for the non-governmental organization (NGO)-summit and a business-summit for the business community. But the funny thing is that the results of the summit, the papers and documents, give the impression that the WSSD was an ordinary science symposium.

One of the major outcomes of the WSSD is the "Plan of Implementation". Analysing this document just in counting the frequency of selected words gives the following result:

Science (and scientific):	46
Research:	35
Knowledge (and know-how):	42
Capacity-building:	41
Values:	9
Ethics:	4
Wisdom:	0

Due to the role of science and capacity-building that is seen in the implementation document many scientists are cautiously optimistic - even after this summit. But some scientists - more than bureaucrats and politicians - have the conviction, that science and capacity-building for sustainable development, especially, have to foster value shifts to sustainable and local wisdom, since ethics-based wisdom combines both knowledge and values. In that respect the "Plan of Implementation" heavily neglects the latter.

From scientific point of view it's obvious that the Johannesburg Plan of Implementation, the Political Declaration and the Type II Partnerships are not enough. Sustainable development is not high in the agenda of national parliaments and policy makers, therefore it is not well placed in the agenda of high international politics. But pointing fingers at the politicians and putting the blame on them would be foolish. The way scientists can realise what (they think) has to be done either can be managed through influencing political decision directly or via "civil society". With the help of the public, there is a lot that science has achieved in the past, for example the Montreal Protocol, signed in 1987. The problem of ozone depletion as such was initially identified by the scientific and environmental community. High-profile meetings and actions by non-governmental organizations then convinced the relevant (political and industrial) actors, even before there was conclusive scientific evidence.

There are parallels with the today's Kyoto Protocol discussion. Companies that use large amounts of fossil fuel are clamouring for solid political commitments on carbon emissions. This industry is understandably reluctant to invest in infrastructure that may be outmoded in a few years' time. Actions that change behaviour without firm commitments from government are known as "type-2 – partnership initiatives" in the arcane parlance of the Johannesburg meeting, and have great potential to allow scientists and industry to address some of the critical issues of sustainable development. Two questions challenge the validity of type II – measures. First, are they going to become a practical and active reality in terms of capacity and institution building? Second, will these partnerships be enough to address the vast, major needs of sustainability. The scientific community could be relatively optimistic with the first question. Many important, promissory initiatives, in terms of design and funding, that can comply with those objectives were announced at the WSSD in Johannesburg. It only has to be ensured that they are really contradictory to existing unsustainable policies and of subsequent long term effectiveness. About the second question we should be more sceptical. The environmental and social problems are so large and so significant that "coalitions of the willing" and "voluntary partnerships" cannot replace the role of public policies, directives, laws, governance and institutional frameworks that need to transform and enforce the behaviour of societies and individuals, the ultimate factor of change to address international, national and local unsustainable status-quo situations.

As implied above, much of the knowledge needed for advancing sustainability goals involves making sense of how multiple environmental stresses, social institutions and ecological conditions interact in particular places. This means that science systems for sustainability will need to give special emphasis to integration at intermediate or regional scales (National Research Council, 2002). From this base, they will need to be structured to facilitate "vertical" connections between the best research anywhere in the world and practical experience in particular field situations. At the same time, they will need to foster "horizontal" connections among regional research and application centres that might learn from one another like the Knowledge Network of Grassroots Green Innovators demonstrates (see homepage list).

There is much that scientific expertise can achieve, especially in deploying existing know-how in the places where it is most needed. There is an abundance of high- and low-tech solutions to water management and energy generation in countries that lack advanced infrastructure. Yet they need to be put in place in a rational way. But also the rich countries have much to gain from sustainable-development research. For example, the development of rural or coastal areas is regulated largely by local authorities, whereas the impacts of such development are often felt in the capitals great distances away. Fishermen and farmers can be introduced to scientifically informed approaches to fisheries management and agriculture where policies are lacking.

Finally, effective science and research systems for sustainability will need to bridge the artificial and pernicious divide between “basic” and “applied” research (Bronscomb et al., 2001). Progress on some of the most urgent problems of sustainability will almost certainly require fundamental improvements in our understanding of nature-society interactions. Thus, sustainability science needs fundamental research. On other issues the requirement is less for new knowledge than for learning how to apply what is already known in an experimental, problem-solving and solution-oriented mode. Sustainability science needs to be learning-by-doing. Sustainability science needs to be pro-active, pro-participatory and highly involved in the development process. More generally, promoting sustainability needs integrated *knowledge systems* that connect what have too often been the “island empires” of research, monitoring, assessment and operational decision support. And finally science and knowledge systems will be measured and appraised by real success in achieve higher sustainability.

4. What is on the science agenda - before and after Johannesburg?

High on the researchers' agenda is the problem of getting existing scientific expertise to where it is needed. It is arguable whether the techniques, tools and experience to do the work on the spot already exist. Geographical information systems, which combine spatial information on a particular geographical area with environmental, social and political data, have become more advanced and less expensive over the past decade. Action and participatory research, monitoring technologies of the environment and the understanding of eco- and social systems have also matured since the Rio summit. Also on the agenda is to ensure global access to scientific data and information. It is necessary to have adequate global scientific information (and monitoring) systems in place. Remote (environmental) sensing plays an important role, but it is also necessary to develop adequate monitoring of social and economic variables and to provide this data to the public.

The advances represent a unique opportunity to study for the first time resource use, climate change and the relationship between health, the environment, social and economic development. As technological advances dramatically increase the ability to obtain, store and analyze data, the digital divide between the North and the South is increasing rapidly (Kates *et al.*, 2000). As a lead-up to the UN World Summit on the Information Society (December 2003), ICSU has announced that it will probe issues that are making scientific data and information more difficult to access - especially for developing nations. For example, research is increasingly being funded by the private sector, and organizations are intent on retaining ownership of their findings or generating revenue from intellectual property rights. In other cases, governments are looking for ways to commercialize data collected using public funds. At the same time, there is no consensus on how to pay for international and global monitoring systems.

All these tools are rarely focused on producing results that politicians and decision-makers can use. A lot of data produced by researchers never finds its way to policy, governments or other authorities. Also major international projects commonly have problems creating such 'policy-relevant' science. The Intergovernmental Panel on Climate Change (IPCC) for example, is widely admired for having communicated a strong scientific message amid the lobbying of industrial groups and environmental activists. But because the IPCC's reports are global in scope and contain huge amounts of data, it is difficult for policy-makers concerned with local issues to make use of them. As a conclusion: The crucial synthesis is linking local action to the global level.

Sustainability researchers face an exciting journey: linking global necessity with the local scale. Many local projects focus on single issues and forget to consider all dimensions of sustainability. What is needed, according to sustainability experts, is the expansion of local research projects so that they address the sustainability of all resources at a particular location at once. Such projects are beginning to emerge. Last year saw the launch of the Millennium Ecosystem Assessment. MEA is an ambitious endeavour to assess the impact of factors such as shifts in land use and loss of biodiversity on the Earth's ecosystems. Information from fish stocks to nitrogen cycles is going to be produced. But the data generated are not just for specialists. The MEA focuses on services of those ecosystems that people actually care about. MEA is of evident local interest.

For instance an MEA study of Norwegian ecosystems should help their government to decide how its fishing and oil-exploration industries can be expanded or transformed without further damaging marine ecosystems. Other MEA members are providing technical support to studies in western China or in Mexico's Yaqui Valley. There, the MEA project goes several steps further. By involving local researchers and politicians, research teams hope to produce data that can directly influence the development of the region. The effects of land and chemical use, irrigation schemes and crop type on the local ecosystem are all being studied, as well as the impacts of external factors such as agricultural policies, globalized markets and drought. By combining this knowledge, researchers hope to reveal how these factors affect the terrestrial and aquatic environment and the income of farmers and city dwellers. Decisions made in one part of the system, concerning one sector, cascade through the system, affecting many other sectors. As with many other sustainability projects the Yaqui Valley project is a "work in progress". The scientific community hopes, that with more information - particularly on the human societies at local level - a truly integrated approach will be possible.

5. How many dimensions does capacity-building have?

Capacity building is a critical element for sustainable development and has been highlighted during the WSSD preparatory process. At the suggestion of ICSU, one of the two dialogue sessions during PrepCom IV focused on capacity building. It has also been widely discussed at the WSSD science forum. Discussions over how to improve scientific expertise and infrastructure for enhancing sustainable development in developed and developing countries - “capacity building” in the sustainability jargon will be limited by the lack of new money made available at the political summit. Projects that focus on local sustainable development could serve as a template for sustainability studies in other areas, but implementing similar studies or initiatives in other parts of the world could prove more difficult. The rich North has a good science base, but many countries, e.g. in Africa, would have difficulties in collaborating with OECD countries.

Nations around the world, both in the South and in the North, are experiencing a dramatic decline in interest for the natural sciences amongst young students. At the same time, a large proportion of the current generation of scientists is approaching retirement. To complicate matters further, scientists are being pulled in opposite directions: they need to be specializing to compete in cutting-edge disciplinary research, yet broader approaches are needed to deal with problems relevant for society. Some would argue that the scientific divide is even greater than the digital divide. Some scientific initiatives are exploring various initiatives to strengthen and coordinate efforts amongst research partners to address the issues around developing scientific capacity in all countries. Amongst them there is ICSU and the RING

Alliance, the Regional and International Networking Group, a global alliance of research and policy organizations that seeks to enhance and promote sustainable development through a programme of collaborative research, dissemination and policy advocacy. Topics of discussion include science teaching at primary and secondary levels, specialization vs. inter- and transdisciplinarity, capacity building, especially at the third world level, scientific networks for sustainability sciences and the challenges of institutional support. Networks of scientists are one the most important ways to tackle capacity building. They provide sharing of produced scientific knowledge, identification of common interests, understanding of impacts, dissemination and information gathering and support through sharing of facilities (Swiss Commission for Research Partnerships with Developing Countries, 2001).

Political and institutional decisions must be translated to fellowships for highly qualified education, programmes for young scientists, networks of institutions of excellence, sharing of innovative experiences, clusters of centres of excellence (like the US cooperation with India) solving practical development problems, developing international programmes, strengthening national academies and pushing political action in intergovernmental bodies. There is a need for a strategy on showing successful stories and cases to politicians, telling them what other countries are doing and how countries can learn from each other. In Africa, some countries are devoting important resources to science and technology and their example must be showed to others and followed.

Scientific networking in the 21st century has to provide an essential further step: "institutional networks". Institutionalization is more than just sharing. It strengthens the process towards a common research agenda, provides more human capacity and more resources and gives synergies for institutional growth. Centres of Excellence have a role but must be integrated in solid institutional networks. They are catalysts of research and provide capacity building opportunities and peer revision. The institutional networks must also be networks for sustainable development, with a culture of science, with people's participation, based on local realities and addressing the common good, embedded in the society and forming partnerships with governments, the productive sector and the civil society. The objectives should be to develop the social contract with science, supporting endogenous capacities and using diversity to sustain development.

6. What about "best practice examples" in capacity-building?

"Leadership for Environment and Development", the full name of the LEAD-Project, is a prominent example of international capacity building, not only on science but on all sustainable development fields. The objective is finding mid career talented people, in the fields of academia, government, NGO, media and business. The LEAD network is composed by 1500 individuals, from which 30% come from the scientific community. Such networks shouldn't only be established on global scale. Since all sustainability has to have local anchors, local, regional and national networks have to be initiated. Another example is the "Actors-Network Sustainable Austria" consisting of around 140 highly engaged individuals of decision makers from politicians, business managers to civil servants and university professors. One aim of this network is to build up a "human infrastructure" and "social capital" to bring Austria on the track towards sustainability. The "Trieste model", a pure scientific project in international capacity building and supported by UNESCO and IAEA, is driven by the work of the International Centre for Theoretical Physics, the International Centre of Genetic Engineering and Biotechnology and the Third World Academy of Sciences (TWAS). They provide for capacity building in the biggest sense, contributing to the return of scientists to their countries, and transferring know-how and technologies. Trieste is a best practice example of North/South and South/South cooperation.

As a consequence of active capacity-building, some official sustainable development organizations and governments are aiding individuals or are running small projects in developing countries. The Swedish government, for example, is attempting to spread its country's expertise in biomass fuels to the Baltic States. It hopes that use of the fuels, which are made from agricultural waste or specially planted crops, could reduce the Baltic region's reliance on coal and oil as energy sources. One example on larger scale is the European and Developing Countries Clinical Trials Programme, funded by the European Union. The 200 million Euro project, which was unveiled in Johannesburg, aims to establish centres for clinical trials at several locations in Africa by 2006. The scheme's backers hope that generating the right infrastructure and expertise will encourage pharmaceutical companies to run high-quality trials of treatments for diseases such as HIV, tuberculosis and malaria where they are most needed.

A new paradigm of education for sustainable development is set by the "Educational Model Network for a Global Seminar on the Environment". Cornell University as the centre organizes this global network of universities from the United States, Costa Rica, Sweden, Netherlands, India and Australia. It consists in videoconferencing, multiconferencing and satellite communication systems that focus on specific problems, with the objective of transforming institutions and empowering global citizens to cooperatively sustain human, environmental and food systems. Undergraduates and graduate students, working together with faculty form a global learning network based on concepts and theory, using literature from education and social sciences, with a holistic view. The Global learning concept and theory is constructivist, experiential learning, "learning to learn," and uses cognitive psychology. The subject matters are global warming, biodiversity, food security and supply, water and population.

Such projects are significant steps forward, but many researchers still have doubts about whether concepts such as policy-relevant science and capacity-building can be successful on a large scale. Some major challenges faced are still how to decide how individuals and institutes can best collaborate to study sustainability and whether, perhaps by the United Nations, science for sustainable development would benefit from coordination at a global level. Any attempt to clarify these issues could be enormously helpful, especially to the numerous scientists who are interested in sustainability but are unsure how they can contribute (Funtowicz and O'Connor, 1999). Even if scientific organizations within the UN-system or the International Council for Science (ICSU) and its partners can provide a blueprint for organizing the field, big political stumbling blocks remain.

It is not impossible to design and implement effective research and development systems to mobilise science and technology for sustainable development. Some relatively successful international programmes exhibiting many of the characteristics outlined here have already been developed to address problems ranging from increasing agricultural productivity, combating human disease to protecting the earth’s ozone layer. Likewise, there already exist efforts that have made a good beginning in implementing integrated, solution-driven, place-based research and applications programmes in support of sustainability as for example the programme of the Southeast Asia START Regional Centre which is part of the global START Network. START, the Global Change SysTem for Analysis, Research and Training, is another “best practice example” for global networking to encourage multidisciplinary research on the interactions of human and environment affecting and being affected by global changes (see homepage list).

7. How to communicate the "scientific value" of sustainability?

A second challenge for sustainability research is that both politicians and science-funding agencies want to see a short-term return from most of their investments, and preferably in their own country or research area. Money for long-term multi- and transdisciplinary projects is hard to secure and often dries up after an initial outlay. Funding for big UN-research centres (e.g. Consultative Group on International Agricultural Research, CGIAR) from developed nations has, for example, been falling over the past decade. Other areas that are critical to sustainable development are also suffering. Renewable energy sources, for instance, were set high on the political agenda in Johannesburg, but funding for the research in this field has fallen deep by more than half as many developed countries slashing their energy-research budgets.

There are exceptions. Funding agencies in some developed countries are beginning to make greater provision for research that focuses on sustainable development, but the overall prospects are bleak. One explanation is that a four or five-year electoral cycle is not equipped to deal with initiatives that will take 20 years to begin to take effect. And politicians are (by their very nature) unlikely to opt for large, long-term investments. Although individual researchers cannot overhaul political systems, they can ensure that politicians are aware of how much science can contribute to sustainable development. This could in turn lead to changes in funding policy.

One should not forget that the limited actions towards sustainability we already have are predominantly driven by scientific data. Otherwise we would not think about such a topic at all. Often the academic world is struggling over definitions and the reliability of the data. Moreover, science is not particularly good at selling itself, if compared to politics or economy. Communication about sustainability issues is very poor today - even among scientists! Often many scientists cannot properly explain what they are doing to other scientists. So it is too easy to complain that the decision-makers do not understand the problem and the urgency. The key to success will be avoiding such communication problems. A solid description of exactly what researchers can do for sustainable development may provide a boost to everyone involved: from the scientists in developed countries to administrators who control the purse-strings of funding organizations. Only a pro-active involvement of scientists and the commitment of researchers in initiatives for sustaining our world's development can help to break out of the ivory tower.

Science and technology are global but the applications could be very local and relevant, like removing illiteracy and malaria, as targets that we want to achieve. It is not going to solve all the problems but it's just a tool that can help with job creation, access to goods and services reduce mortality rates, improve literacy, access to safe water as a result of improved management, money transactions, and logistic support in disaster recoveries, among others. All modern technologies, especially information technologies, must be sustainable (Strigl, 2001). If people cannot afford these technologies, there are no benefits. They must be accessible and affordable; they cannot be a charity; the poor people must desire it. They should be easy to use and trustable. The scientific community should contribute by placing their knowledge into the network, and the institutions from developing countries, like TWAS for example, could introduce copyright schemes such as charging small royalties for providing information. Intellectual property rights could produce win-win situations and concrete solutions. Multilingual software, support of local entrepreneurs, power development without grids and provision of wide band are greatly needed. Such access to information and know-how is essential for reducing the gap between the North and the South and essential for social welfare in a rapidly changing world.

8. Wanted: scientists with hearts and new ideas – all over the world

Since Rio some progress has been made in the development of codes of practice and guidelines within the science community. Chapter 31 of Agenda 21 presents clear principles on the role of science and sets out the need to develop, improve and promote international acceptance of codes of practice and guidelines recognized by the society (United Nations, 1992). Engineers and medical doctors are bound by professional codes of ethics that state categorically that the public interest, life, safety, and property, overrides private interest in the practice of their profession. The World Federation of Engineering Organizations (WFEO) incorporated a "code of environmental ethics" into its engineering code of ethics. The engineering community also endorsed the "Earth Charter" which calls upon member governments, professionals, and civil society to accept a moral and ethical guide of conduct and to commit to sustainable development. ICSU's "Standing Committee for the Responsibility and Ethics in Science (SCRES)" has completed an analysis of 115 codes of practice and standards from the science and technology community (SCRES, 2002).

Society depends on scientists and engineers as responsible individuals, to guard against negligence and misconduct and to safeguard mankind. Ethical challenges include: conflict of interest, whistle blowing, human rights, free migration of professionals, and research funding. In addition, scientists and engineers are increasingly being called upon to become more engaged with the public and policy makers on highly emotive issues such as food safety, GMOs, gene technology, stem cells, cloning, use of animals in research, and nuclear energy - to name a few. The view of scientists and engineers solely as "independent" knowledge generators has been irrevocably altered by changes in society. Scientists now acknowledge they must take responsibility for the implication of their results, potential uses and abuses, and impacts on people and societies (SCRES, 2002).

Scientific knowledge and new technologies continuously challenge and sometimes change society's values radically. Scientists and engineers have an obligation to contribute to this discussion. No sector of society has more knowledge about issues that generate ethical dilemmas and who also have the capacity to help to resolve them. For that reason, it is important to promote ethical sensitivities beginning with individual scientists and engineers.

Closely related to these ethical concerns is increasing awareness that cultural diversity is a factor that must be effectively integrated within efforts to achieve sustainable development. Each country faces its own challenges and requirements guided by their own culture and values. Most of the scientists welcome the opportunity to engage in an open and constructive dialogue with policy and decision makers and society that will enable us to better reflect the wide diversity of culture and values throughout the world (Gupta, 1999).

A new generation of scientists is needed, particularly for sustainability needs, with a more holistic approach, but not only in the rich developed states. How can we ensure that science is done everywhere? Input and work coming from "Diaspora", or repatriating scientists can be a solution, but nothing replaces the need of developing a home-based scientific capacity (Binder, 2002). New programmes for Ph.D. training are needed taking into account special needs of sustainable development, as well as competitive research grants. It is very important to not forget young scientists. On an individual or institutional level, researchers can begin to foster relationships with their colleagues in poor countries and to look for ways to apply their research to sustainable development.

Scientists, working in concert with others, are showing that they can help to steer the world towards a more sustainable future. Several multidisciplinary projects that are well suited to informing sustainable policy decisions have been created over the last years - for example the mentioned Millennium Ecosystem Assessment. Plans are also afoot to reinforce much-needed scientific knowledge and research capacity in the developing world and there already exist some capacity (Swiss Commission for Research Partnerships with Developing

Countries, 2001). Efforts funded by the World Bank to introduce more fuel-efficient cooking stoves have begun to pay off by reducing biomass burning and respiratory disease in places such as China and India. The partnership between the University of California, Berkeley, and Nairobi-based Energy Alternatives AFRICA to establish a photovoltaic electricity industry in Kenya is now spilling over into other African countries. The EU-funded European and Developing Countries Clinical Trials Programme, which was unveiled at Johannesburg, could attract developed countries to carry out the high-quality clinical trials for locally important drugs that are so desperately needed in Africa.

Medical science should be developed in order to meet the threat of newly emerging diseases like AIDS and the return of old diseases such as tuberculosis and malaria that are becoming resistant to present treatments. It is important to improve, promote and spread appropriate agricultural methods, in particular where introduction of industrialised methods of farming have lead to health disasters, destruction of natural biodiversity and traditional sustainable agricultural practices and the impoverishment of rural populations. The manipulation of human, animal and plant DNA must be treated with the greatest caution (precautionary principle). Such developments are irreversible, and scientific methods may fail to predict all the consequences and side effects. The patenting of life forms and the privatization of the knowledge of indigenous people must be prevented. Here the sustainability-group amongst the scientific community has the obligation to find ways and models how to deal with individual property rights, patents, trade-mark and copy-right protection whilst the poorest are suffering or being exploited from "protected" products and technologies and the rich still prosper from this asymmetry.

Last but not least the spectrum of economic schools of thought to be heard in decision making processes and being taught in schools and universities must be widened. Neo-classical economics, for all its merits and harm, is unable to grasp important aspects of sustainable development. In many instances, it is more a part of the problem than of the solution. Other economic schools of thought like ecological economics provide insights that are essential for any policy towards sustainability and these should be properly valued. An important resource scarcity of the future could be the brainpower of heterodox economists.

9. Conclusion: what does the new contract between science and the public looks like?

The magnitude of human impacts on the ecological systems of the planet is apparent. There is also increased realization of the intimate connections between these systems and human health, the economy, social justice, and national security. The urgent and unprecedented environmental and social changes challenge scientists to define a new social contract (Lubchenco, 1998). This contract represents a commitment on the part of scientists to devote their energies and talents to the most pressing problems of the day. Addressing social equity, poverty reduction and other societal needs must be integral to scientific, engineering and technological endeavours. The historically new and yet unmet needs of society include more comprehensive information, understanding, and technologies for society to move toward a more sustainable biosphere, which is ecologically sound, economically feasible, and socially just. New fundamentally deep and accurate science, pro-active and committed research that contributes not only to knowledge accumulations but also to a sustainable change, faster and more effective transmission of new and existing knowledge to policy- and decision-makers, and better communication of this knowledge to the public will all be required to meet this challenge. In turn, society has a responsibility to provide adequate funding, up-to-date research facilities, and appropriate career structures, as well as opportunities to inform and participate in the decision making process. Such an effort requires a new contract between science and society in which ethical dimensions play a central and guiding role.

There is no doubt that (harnessing) science and knowledge-building have to become vital forces for sustainable development. Such a development depends on processes that will ensure the involvement of all appropriate (scientific) input and expertise in problem identification and response. Scientific excellence and integrity needs to be combined with a close dialogue and cooperation with policymakers, stakeholders and implementers Funtowicz and O'Connor, 1999). This includes full participation by experts with local and regional knowledge and wisdom in developed and in developing countries, since sustainability is a global challenge. Many scientific institutions asked an indispensable question: Can real sustainability be reached without involving stakeholders? Their findings confirm that first and foremost, effective research and knowledge-building systems for promoting sustainability will need to be structured so that they are driven by the most pressing problems of sustainable development as defined by the people themselves (and not only by experts). In this respect "sustainable development" has to act as the solution to these problems and is therefore highly vision-oriented driven. This will almost certainly result in a much different agenda from one that would be obtained by continuing to allow priorities to reflect primarily the most acute problems (in science, knowledge and capacity-building) as defined by stakeholders in research and innovation. As suggestions for some key elements in the development of the necessary new quality assurance, science communication and public policy processes there are:

- new institutions, networks and public procedures for the social evaluation of science advances,
- a shift in emphasis from one-way technology transfer to participatory learning and capacity-building,
- a reassessment of the forms and locations of the "centres of excellence" capable of contributing knowledge and judgement needed for sustainability,
- and a reassessment of funding and financial support of research programmes and centres.

Many of the challenges for sustainable development involve issues and triggering mechanisms that are global, long-term and complex. Yet solutions need to be, for a large part, concrete, simple, short-term and local. To overcome this gap the purpose of different programmes and initiatives towards sustainable development e.g. Local Agenda 21 (United Nations, 1992) is to build local capacity and private-public-citizens partnerships for action. These processes are not only observed and monitored but often initiated and facilitated by pro-active scientists, researchers and others. Such processes can be seen, on the one hand, through the development of sustainability visions, targets, action plans and indicators appropriate for different scales. On the other hand, they bring stakeholders together at local levels and across levels, to define options for collective action. This develops new forms of governance and participation and can be seen as a strong tool to reinvent democracy. Multi-sector involvements through local stakeholders' networks are complementary to formal democratic institutions for implementing sustainable development policy. In that respect sustainable development actors have the task of "reinventing" democracy.

Generating, sharing and utilizing science to improve and integrate policy is a question of: scientific communication, international cooperation and capacity-building for sustainable development. These are some of the new challenges that the quest for sustainable development poses to scientific research and the interface between science and policy. One of the issues fundamental to both science and policy is that of integration. Integration of scientific research requires a systemic approach, inter- and transdisciplinary research style, and the consideration not only of the relevant quantitative data but also the relevant qualitative information (Scholz, 2001). Appropriate mechanisms for making science available to policy-makers must include team-based social and regional approaches.

However, in Johannesburg it was recognized that to achieve real sustainable development, true inter-paradigmatic dialogues are necessary. Things to do or to take into account by groups dealing with science in support policy were also discussed. The fact that the high complexity of natural and societal systems implies a degree of irreducible uncertainty should not be interpreted as total ignorance and a licence for “anything goes” or “never touch the American life-style” in the policy realm. Adaptive and participatory pro-active approaches contrast with command-and-control approaches. In many cases, scientific research does not produce the kind of policy-makers in the scientific enterprise. This world summit showed however, that innovative experiments on how to generate a dialogue between science and policy are needed. ICSU has demonstrated its commitment to the political process, and is now intent on further defining the focus of new initiatives in this area that are focusing the real threats of food security, global environmental change, loss of biodiversity and geohazards. Some weeks after WSSD delegates from the scientific community are eager to advance their role in organizing a global action plan for science and technology.

“Following what was, for many, the disappointing political outcome of the World Summit on Sustainable Development (WSSD), it is very exciting for the ICSU to reach agreement on the need to roll up our sleeves and generate an action plan for science for sustainability,” said Professor Jane Lubchenco, ICSU’s new president at the General Assembly in October 2002. “Our top priority is to take an integrated approach to addressing the economic, environmental and social pillars of sustainable development.” As a common conclusion and basic result of the Johannesburg summit all delegates shared the strong hope that a world society that tries to turn towards sustainable development has to work hard in refine their clumsy technologies, in "earthing" their responsibility to all creatures and resources, in building up global solidarity through all mankind and commit themselves to a better live for the next generations. The most intimate formula for sustainable development scientific community found is earthing responsibility in respectfulness, tolerance and solidarity. This might be the only way to create global wisdom.

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Consultative Group on International Agricultural Research (CGIAR): http://www.cgiar.org/
Global Change System for Analysis, Research and Training (START): http://www.start.org
International Council for Science (ICSU): http://www.icsu.org
International Foundation for Science (IFS): http://www.ifs.se/index.htm
International Science Programme (ISP): http://www.isp.uu.se/Home.htm
Knowledge Network of Grassroots Green Innovators: http://www.sristi.org/Nissat.htm
RING Alliance: http://www.ring-alliance.org/index.html
Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI): http://www.sristi.org
Southeast Asia START Regional Centre: http://www.start.or.th
Third World Academy of Sciences (TWAS): http://www.twas.org
Third World Network of Scientific Organizations (TWNSO): http://www.ictp.trieste.it/~twas/TWNSO.html
United Nations Millennium Ecosystem Assessment: http://www.millenniumassessment.org/en/index.htm

List of abbreviations

CGIAR	Consultative Group on International Agricultural Research
COMSATS	Commission on Science and Technology for Sustainable Development in the South
ICSU	International Council for Science
IFS	International Foundation for Science
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISP	International Science Programme
MEA	Millennium Ecosystem Assessment
NGO	Non-governmental Organisation
ODA	Official Development Aid
PrepCom	Preparatory Commission for the World Summit on Sustainable Development
SCRES	The Standing Committee for Responsibility and Ethics in Science
SRISTI	Society for Research and Initiatives for Sustainable Technologies and Institutions
TWAS	Third World Academy of Sciences
TWNSO	Third World Network of Scientific Organizations
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFPA	United Nations Populations Fund
WB	World Bank
WCED	World Commission on Environment and Development
WGBU	German Advisory Council on Global Change
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization