23–24 AUGUST 2006
YOKOHAMA, JAPAN

INTERNATIONAL CONFERENCE

Globalization: Challenges and Opportunities for Science and Technology

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FOREWORD

In today's increasingly interconnected world, people from all continents and backgrounds are able to exchange ideas and broaden their horizons. This is the most immediately visible impact of globalization, but not the only one. Globalization will have far-reaching consequences for all areas of human endeavour – including science and technology and their impact on development.

Globalization's impact has been and continues to be unequal. For some – individuals and countries alike – it has meant opportunity for advancement. However, for others globalization has meant exposure to increased competition, marginalization and impoverishment. The challenge is to harness the processes of globalization, learn from them, and adapt best practices so as to reinforce the beneficial aspects of globalization while mitigating its negative effects.

Advances in scientific knowledge and its technological applications are potent drivers of globalization. Equally, globalization strongly influences the ways in which scientific knowledge and new technologies are produced, put to use and disseminated. Indeed, research and development agendas are defined not only by local or national needs, but also by the requirements of the global marketplace. Both access to and creation of knowledge have become crucial factors for social and economic development in today's globalized world.

The International Conference on "Globalization: Challenges and Opportunities for Science and Technology" was jointly organized by UNESCO and the United Nations University, (UNU), on 23-24 August 2006, in Yokohama, Japan. It was the fourth opportunity, in what has now become an annual event, for our two organizations to join forces and collectively brainstorm on the challenges and opportunities of globalization – this time to deal specifically with questions relative to science and technology. UNESCO and UNU are well placed, as multilateral agencies involved in education and science, to address these issues.

Working in synergy with UNU – who's objective is to generate and transfer knowledge – demonstrates one of the many ways that UNESCO works "as one" with sister organizations within the UN system to increase the knowledge base at the disposal of our Member States.

This conference brought together decision-makers, academics, members of government, and leaders from various facets of civil society to discuss ways in which to better, and more directly, harness scientific and technological progress for the promotion of peace and sustainable development. The large number of participants, hailing from many regions, reflected the importance science and technology has taken on in the international agenda. The Conference explored salient issues such as access to knowledge and benefit sharing, the scope of intellectual property protection, and the ethical boundaries of scientific enquiry. At the centre of the discussions was the creation of knowledge societies in which science and technology are neither the sole realm of academics nor the preserve of an elite segment of society enjoying a privileged access to the benefits and products of scientific achievement. Rather, these knowledge societies should utilize the processes of globalization to foster knowledge creation, sharing and diffusion for the benefit of all.

It is in this spirit that I am pleased to present the record of this highly successful two-day Conference. I hope this publication will help stimulate a broader debate about the challenges and opportunities inherent in this area. Properly harnessing science, technology and globalization for the benefit of all is an essential step towards achieving a sustainable and peaceful world.

Koïchiro MATSUURA
Director-General of UNESCO

INTRODUCTION

Koïchiro MATSUURA

Director-General,
United Nations Educational,
Cultural and Scientific Organization (UNESCO)

Throughout a long and distinguished career with the government of Japan, Koïchiro Matsuura served in many posts, including as Ambassador of Japan to France, and concurrently to Andorra and Djibouti (1994–1999); Deputy Minister for Foreign Affairs, Japan (1992–1994); Director-General, North American Affairs Bureau, Ministry of Foreign Affairs (1990–1992), Director-General, Economic Cooperation Bureau, Ministry of Foreign Affairs (1988–1990); Consul General of Japan in Hong Kong (1985–1988); Director, General Affairs Division, and Deputy Director-General, Foreign Minister's Office (1982–1985); and Director, Aid Policy Division, Ministry of Foreign Affairs (1980–1982). He was Chairperson of the World Heritage Committee of UNESCO in 1998–1999.

SCIENCE AND TECHNOLOGY: BRIDGING THE INEQUITIES OF GLOBALIZATION

It is my great pleasure to welcome you here today to the UNU/UNESCO International Conference on Globalization. This year's event will focus on "Challenges and Opportunities for Science and Technology", a subject of crucial importance, but one that has not always received the attention it deserves.

I wish to begin by thanking the distinguished speakers and participants who have come from near and far to be with us here in Yakohama. Such widespread participation reflects both the prominence of globalization on the international agenda, and the deep-felt need to gain a better understanding of its nature and impact.

I would also like to thank those who have helped organize today's Conference. First of all our host, the UNU, and in particular its Rector, Professor Hans van Ginkel. It is thanks to his commitment and vision that the UNU/UNESCO Conference has become a well-established annual event, attracting international experts to analyze and discuss the various dimensions of globalization. I wish furthermore to thank the Government of Japan, as well as the National and City Universities of Yokohama, for their generous support, which is deeply appreciated.

The complex phenomenon of "globalization" is – and for the foreseeable future will continue to be – a major trend, affecting all spheres and levels of society. The early, often passionate, debates about the relative desirability of globalization, have now given way to the growing recognition that this process is not just irreversible, but also probably unstoppable. However, while globalization may now appear inevitable, the direction and form it takes is something we can – and must – work to shape. It is our responsibility to ensure that globalization serves human interests and is of benefit to all.

So far, the impact of globalization has been unequal. For certain sections of the world community it has been a force for economic growth and social mobility, opening up new opportunities for participation and communication. For too many others, however, globalization has led to deeper marginalization and impoverishment, widening disparities both within and between countries. Those who suffer from globalization are invariably these already struggling with exclusion: the poor, women, ethnic minorities and youth.

Much of UNESCO's work in recent years has been focused on bridging these inequities. The commitment to "globalization with a human face" is a strategic priority for the Organization, and directs all our major programmes. Our prime concern is to render globalization more just by empowering people to escape exclusion and discrimination, and by empowering countries to become equal actors in the global arena.

Science and technology are keys to such empowerment. They are central to enhancing access to knowledge – an essential commodity in today's world. Information and communication technologies (ICTs) have revolutionalized the role of knowledge in our societies, making the availability of information – and the ability to employ such information effectively – an increasingly critical determinant of economic growth and sustainable development. UNESCO is committed to promoting equal access to new technologies and to providing information for all. The Organization also works to ensure that individuals and societies can make use of such information to preserve and improve their way of life. Policies to provide universal quality education, to promote respect for cultural and linguistic diversity, and to secure freedom of expression are all crucial in helping to bridge the digital and knowledge divides.

Science and technology also have a central role to play in overcoming many of the other social and economic inequities that act as barriers to empowerment. Our success in achieving the Millennium Development Goals (MDGs) to eradicate extreme poverty, reduce child mortality, improve maternal health, ensure environmental sustainability and combat HIV and AIDS, malaria and other major diseases – our success in all these areas will require focused science and technology policies. It will also require concerted efforts to strengthen developing country capacity to lead and manage scientific research and development.

A well-functioning and inclusive education system that delivers high quality education for all is a basic precondition for any effective science and technology policy. Quality education creates the human capital required for research and development and for finding innovative solutions to fundamental global challenges. Of equal importance is the need to strengthen linkages between institutions of higher education on the one hand, and industry, government and private research institutes on the other. The formation of such a holistic national innovation network will be instrumental in the transfer and commercialization of scientific research for economic and social development.

UNESCO is closely engaged in science and technology capacity building, both at the individual and institutional levels. For example, the Organization is working closely with the New Partnership for Africa's Development (NEPAD) of the African Union, and with individual countries like Nigeria, to develop effective and replicable capacity-building strategies. UNESCO is also assisting African universities in developing scientific and technological capacity specifically targeted to addressing regional challenges. In this regard, we are privileged to have present here today the Commissioner of the African Union for Human Resources, Science and Technology, and the Minister of Science and Technology of Nigeria – I look forward to learning of your experience and vision for the future.

Harnessing the full potential of science and technology for sustainable development implies a strong focus on global knowledge exchange, networking, and advocacy. UNESCO – in its role as an intellectual clearinghouse and knowledge broker – has unique capacity in these areas, in particular with respect to facilitating cooperation at the international level.

Indeed, the impressive growth in technical skills and institutional capacity in almost all developing countries has opened up promising perspectives for international collaboration. The Academy of Sciences for the Developing World (TWAS) already offers a key forum for promoting scientific dialogue, and serves to focus joint scientific research on specific regional development problems.

UNESCO's International Basic Sciences Programme (IBSP) likewise aims to strengthen regional and international cooperation. Working through a network of national, regional and international centres of excellence, the Programme focuses on enhancing scientific capacity in development-oriented areas of national priority. It seeks to promote both South-South and North-South collaboration, along the lines laid out in the Doha Declaration and Plan of Action.

While working to enhance international cooperation, it is important not to neglect those who are usually left out of knowledge and science networks – in particular women and youth. Specific action is needed to enable female researchers and scientists to compete and succeed on a fair and equal basis. The under-representation of women in science marks a great loss of human potential. It is also strategically important to engage and motivate young scientists, at all levels of the education system. Only by inspiring and training young minds will we maintain the momentum of scientific progress in the future.

Let me now turn to the role of science and technology in promoting sustainable development. Growing environmental pressures, and increased threats to natural resource bases, biodiversity and ecosystems, have made the need for carefully targeted science and technology policies ever more critical. Here, I would like to briefly outline some of UNESCO's policies in two key areas of development: freshwater and oceans; and natural energy resources.

Freshwater and oceans now stand at the top of the international agenda and, within the UN system, UNESCO is taking a lead role in both fields. The challenges here are vast and urgent. Water pollution and the destruction of related ecosystems have assumed alarming proportions, and climate change has led to an increase in natural disasters which place the lives of whole communities at risk. Many countries are still not on track to reach the water-related targets of the MDGs, and millions of people die each year from treatable waterborne diseases. Around 40 per cent of the world's population have no access to basic sanitary facilities.

In its science programme, UNESCO focuses on tackling these problems through a three-pronged approach aimed at: first, enhancing scientific, technical and human capacity to improve water management; second, strengthening our knowledge base through the provision of comprehensive water education and training; and third, assessing the state of the world's oceans and freshwater resources. Furthermore, through its Intergovernmental Oceanographic Commission (IOC), UNESCO is working to reduce scientific uncertainties about the health of the marine environment, and to enable the prediction of climate change and its effects on ocean resources.

The question of providing access to sustainable energy resources is another pressing challenge. UNESCO's efforts focus on human resource development, and on promoting increased energy efficiency and diversification, notably through the large-scale use of renewable – in particular solar – energy forms. The dramatic increase in global demand for mineral and energy resources also requires action in the earth sciences. UNESCO, as the only UN agency engaged in research and training in geology and geophysics, is leading efforts to develop research and capacity-building in these areas.

Global vulnerability to natural and manmade disasters is increasing, for many populations disproportionately. In the face of such hazards – and drawing on the Organization's ability to assist in prediction, early detection, and building preparedness – UNESCO has focused its efforts on developing a culture of prevention. This involves not only the effective use of scientific and technical advances to inform preventive action, as for example in the case of creating an effective Tsunami warning system. It also extends to education, knowledge management and raising public awareness.

One final issue to which I wish to draw attention is that of the ethics of science and technology. With the growth of scientific knowledge and technological innovations, the need for ethical principles to regulate their implementation has become increasingly important. This is especially the case in fast-developing scientific fields like genetics. Efforts here are needed to ensure that science and technology are oriented towards human welfare and are respectful of individual rights. As UNESCO has long advocated, the ethics and responsibility of science should be an integral part of the education and training of all scientists.

Today's conference provides us with an excellent opportunity to discuss all of these questions. It enables experts from different countries and backgrounds to explore together the transformative potential of science and technology. Above all, it encourages us to focus on how this potential can be mobilized to successfully shape globalization to the benefit of all.

Hans van GINKEL

Rector, United Nations University (UNU)
United Nations Under-Secretary-General

Prior to joining UNU, he was Rector of Utrecht University, the Netherlands (1986–1997). From 2000 to 2004, he served as President of the International Association of Universities (IAU), and is currently Vice-chair of the Board of Trustees, Asian Institute of Technology (AIT, Thailand); a member of the Academia Europaea; and Honorary Fellow of the Institute for Aerospace Survey and Earth Sciences (ITC, the Netherlands). Among his many distinctions and awards is "Knight in the Order of the Netherlands' Lion", received in 1994. Rector van Ginkel holds a Ph.D. degree from Utrecht University and honorary doctorates from universities in Romania, USA, Ghana, and Slovakia. His fields of interest are urban and regional development, population, housing studies, science policy, internationalization, and university management. He has published widely and contributed extensively to the work of various international educational organizations.

“GOOD COOPERATION IS VISIBLE IN SMALL THINGS”

It is a great honour and pleasure to welcome you all to the UNU/UNESCO Conference on Globalization: Challenges and Opportunities for Science and technology.

I would like to start his remarks by saying that “Good Cooperation is Visible in Small Things”. However, in an increasingly competitive and globalized world, cooperation is not always easy. Nevertheless, where the effort is made, it can lead to great success — as evidenced by major breakthroughs in modern science. Whether the success is big or small, however, cooperation will always be visible in (many) small things.

Such good cooperation has been growing over recent years between UNESCO and United Nations University (UNU), based on the complementarity of our missions as well as on good relations and respect for the contributions of our diverse expertise. This cooperation is intensive in areas as distinct as access and benefit sharing of deep-seabed genetic resources; strategies to prevent deserts from expanding, or to expand and improve agriculture in marginal drylands; the protection of mangrove forests in Asia and the Pacific; improvement of the quality of life and prevention of land degradation in the mountains of Central Asia; the prevention and proper management of floods, landslides, and other disasters; and education for sustainable development.

Good cooperation becomes visible in seemingly small things. To facilitate such cooperation, UNUESCO Director-General Matsuura and I have established an exchange program that enables one researcher from each organization to work at the other each year, for some weeks or even months, on a project of mutual interest. In this way, we can learn effectively about what is being done and planned in both organizations, and thus ensure optimal preparation and implementation of all projects that have our shared interest. A number of Japanese universities are also involved in this cooperation, including some in the Kanto Region and in Kyoto, Tottori, Hokkaido and Okinawa.

One example of the consistent cooperation between UNESCO and UNU is a series of annual conferences, begun in 2001, that deal with the challenges and opportunities posed by globalization. The shrinking of distances and the opening up of markets and borders have inevitably had a great impact in many sectors of our daily life. To understand this impact and help ensure that globalization benefits all, these conferences have addressed several critical issues, including the hidden dimensions of globalization (such as those relating to social, cultural, and religious life); dialogue among civilizations; intangible cultural heritage, like music, dance and literature; or education for sustainable development for all, both inside and outside schools.

This year’s conference focuses on the interlinkages between globalization and science and technology. While globalization processes are, in part, driven by science and technology

— particularly, new information and communication technologies — globalization in turn has strongly influenced the ways in which scientific knowledge and new technologies are produced and disseminated. The impact of globalization has been largely positive, offering new opportunities to promote social and economic development for the benefit of all. In some of the developed countries, in particular, science and technology are developing with breathtaking speed.

Knowledge is becoming an ever-more important strategic advantage for a seemingly decreasing number of countries. To prevent the race to the top from leaving more and more people behind, in both developed and developing countries, the sharing of knowledge, making use of all the communication tools we have at our disposal, is becoming crucial. Only through such sharing can globalization and the progress of science and technology be made to benefit all in, for example, human (including economic) development, health care, environmental issues, disaster preparedness, and the safe and dependable provision of water and energy.

Yet globalization has also created new challenges and policy questions that cannot be ignored. Increasingly, ethical questions have emerged in the international debates on such topics as bio-diversity, genetic research, cloning, or stem cell research. There are also questions of intellectual property rights and knowledge sharing. The uneven distribution of an increasingly important production factor — knowledge — may now be the ultimate difference between economically successful and less successful (even failing) countries, and between rich and poor. And increasingly, given that the development of knowledge is so expensive, doubts are being expressed about capacities to continue to contribute to the next stage.

Knowledge transfer has, therefore, become a top issue in all trade negotiations. I am reminded of a remark made by one of my mentors, Prof. Walter Kamba from Zimbabwe, former chairperson of the UNU Council: "Do you think that knowledge is expensive? Try the opposite!"

It is therefore vital, I believe, to explore further the relations between globalization and the development of science and technology and, in particular, to understand and strengthen the role of science and technology anywhere so as to improve the human condition everywhere; to improve all the issues that matter to every person: food, water, shelter, health, environment. These are the issues on which we, in UNESCO and UNU, focus. It is in many small things that good cooperation becomes visible; through people cooperating in projects, sharing their thoughts and knowledge. People building the common future of humankind through creative, innovative science and technology has proven to be capable of making highly valuable contributions. This will be the focus of the discussions in this year's conference.

Finally, I would like to thank all of you for coming here today and for participating in this two-days conference. I wish you will find the issues addressed in this year's conference stimulating and educational.

KEYNOTE PRESENTATIONS

H.R.H. Princess Maha Chakri SIRINDHORN

UNESCO Goodwill Ambassador

Princess Maha Chakri Sirindhorn has served as Executive Vice President of the Thai Red Cross Society since 1977, as Faculty Member and Administrator of the Chulachomklao Royal Military Academy since 1980, and as Executive chairperson of Chipattana Foundation since 1988. She has undertaken development projects in school-based development, IT funds for the disadvantaged, biodiversity and plant genetic resources, and water resource and alternative energy development. The Princess currently serves as Council Member of the Refugee Education Trust, World Food Programme Goodwill Ambassador, and UNESCO Goodwill Ambassador. She received the Ramon Magsaysay Award (Public Service) in 1991 and the Indira Gandhi Award (Peace, Disarmament, and Development) in 2004. She holds an Ed. D. degree in Developmental Education.

SCIENCE, TECHNOLOGY AND DEVELOPMENT

INTRODUCTION

Science and technology have enhanced the capacities of human beings in utilizing and transforming environments to meet their needs. In the past few decades, scientific and technological advances have caused very rapid changes in human societies. We can say that science and technology speed up development, and in turn development catalyzes science and technology advancement. They have evolved together and are indicators of one another.

Development is a process leading to progress or change for the better. The goal of development workers is sustainable development to improve livelihood of the people without destroying the environment. One must recognize that development varies with culture, geography, religious belief, ethnicity and socioeconomic background. Even though there is no "one-size-fits-all" formula of development, success stories usually involve development workers who are caring, responsible and respectful for other human beings. In other words, development involves a lot of humanity and spiritual element.

Science is a study to gain understanding about Nature, from something as small as quantum to the limitless universe. The knowledge of science is useful in our daily lives and careers. The study of basic science also plows the seed of scientific thinking, methodology and research essential for problem solving. Therefore scientific knowledge and scientific process are valuable assets of mankind, and they should belong to all.

Technology is human invention or innovation to facilitate human beings to have comfortable living and to accomplish difficult tasks. Suitable technologies are important tools to achieve successful results and outcomes of development. In any development, science and technology education are necessary, even at the grass root level. We cannot achieve sustainable development if the education component is not incorporated into the plan. What, when, how and how much scientific and technology should be used depend on each circumstance. There are no set rules like appropriate technology for rural development, high technology for urban development. There is also no clear cut border between basic and applied sciences. They are all related.

MY EXPERIENCE IN DEVELOPMENT WORK

Human needs may vary, but everyone needs at least the four basic necessities for life, namely, food including water, habitation, clothing and medicine. These four have had their priorities in all of my development projects.

I have had the privilege of accompanying Their Majesties the King and Queen, my parents, to visit many remote areas in almost every corner of Thailand since I was very young. In the 1970s I had some responsibilities in development work. I met many different kinds of people and had opportunities to observe and analyze their ways of living and needs in their surroundings. Many lived in severe environments without access to any public services, namely, education, health care, etc. In many cases they lacked the basic necessities mentioned above.

At present I am responsible for many development projects, especially the ones related to the Chaipattana Foundation (www.chaipat.or.th/chaipat/noframe/eng/index.html) registered officially in 1988.

The objectives of the Foundation are as follows:

- To support the implementation of Royally Initiated and other development projects.
- To promote the development of social and economic welfare activities to improve the quality of life of the people and to enable them to become self-reliant.
- To carry out plans or projects that are beneficial to the people and the country as a whole.
- To cooperate with the government sectors and other charity organizations for public benefit or to take action that reinforces support of public welfare.
- To carry out activities without political involvement.

The activities of the Foundation can be read from the Foundation's journals (**www.chaipat.or.th/chaipat/journal/journale.html**).

THE KEY ASPECTS OF DEVELOPMENT

I would like to mention a few key aspects of development.

Education is the most important factor to sustain a country's development. Science and technology education should be implemented at all levels, from kindergarten up to secondary and tertiary education. Students should learn both skills and also the power to think in a scientific but imaginative way which will certainly lead to creativity and innovation. To be able to fulfil the educational goals, science and technology are needed, for example, scientific equipments and laboratories, books, journals and other printing materials, computers and computer-related gadgets, etc. For people with disabilities science and technology play an important role in their achievements.

In rural and remote communities, sometimes we have to start from scratch. We build schools or learning centres in villages. Infrastructures like water supply, transportation, clean drinking water, nutritious food, basic medication, have to be provided. Science and technology play an important role in provision of the needed resources. The schools also face the problems of shortage of educational resources, especially teachers in science and technology and teaching staff in general. This problem can be partly solved by providing good library, using information and computer sciences, e-learning, and distance learning. Both teachers and students along with villagers can benefit from such programs.

We hope that our efforts in development will lead to an equal opportunity in education and success in life for all.

Work or employment is another key aspect of development. An adult human person should work, be self-reliant and be able to contribute to others as a good member of the community. In most part of Thailand, agriculture and agronomy remain the major sector. Knowledge and know-how of science and technology can help the people produce enough and have excess products to earn their living. With more knowledge of science and technology, some can get more technical jobs in the industrial and service sectors. Good and secure work gives a person a sense of self-esteem and security.

Agriculture and agronomy are the main targets of most development projects in rural Thailand. They have had great influence on our culture and way of life since the olden days. It is every government's major policy to develop this sector. It feeds the people and provides the basic necessities for the people. In 1997 when the big economic crisis hit Thailand, this sector acted as a buffer to alleviate the damage. Agriculture and agronomy provide good foundation for "sufficiency economy", the term and the concept coined by His Majesty the King, my father, after long years of practice and study. Science and technology can help build the agricultural and agronomic capacities, aiming at an increase of production without going beyond the limits of the environments and the availability of natural resources. The important science and technology used in agricultural development are irrigation and flood control, seed technology, pedology (soil science), post-harvest technology, animal husbandry especially dairy farming which initially is not easy for tropical and subtropical areas, etc.

Fishery has been a main career and food source of Thai people. In the tsunami in December 2004, not only did we lose thousands of lives, including my nephew, but we also lost innumerable fishing equipments. So we need to provide the survivors with many boats. Imagine how many trees would have to be cut down to meet their demands. Luckily, we were able to make fibreglass boats, designed specifically to suit their different fishing skills, thanks to the advancement of material science. The fibreglass boats saved many trees and also a lot of money both for the construction and the maintenance. The advancement of material science improves the quality of those boats. Technologies are also important in the design of the boats and the appropriate machineries.

Fishery is always hit by the soaring oil price. Research in acquiring bio-diesel from plants has been continuously carried on. We have an experimental project using methyl ester from a pilot plant. In the future, the communities will be able to produce some energy to meet their needs.

Sustainable aquaculture is very important for Thai economy. It should be done in a way that it does not put too much stress on environment.

Agro-Industry involves industrial processing of agricultural products. It starts from simple home industry up to sophisticated factory. Knowledge in science and technology is undoubtedly crucial.

Health is one of the most important aspects of development in which the advancement of medical science and technology can help a great deal. However, some treatments and special care are still costly, and we often face ethical dilemmas when it comes to making decision in those cases.

Nutrition is a good preventive measure of health care. Nevertheless introducing nutritious food into a community in which they have their own eating culture may not be so simple. We should understand their culture and emphasize as much local production and local nutritious products as possible.

For about 25 years, I have had the opportunity to work with the schools in the remote areas to solve their problems in nutrition. Cases in severe protein and energy malnutrition are rare now in Thailand. However, there are still some micronutrient malnutrition or vitamin and mineral deficiency, for example, iodine deficiency disorder, iron deficiency, vitamin A deficiency, etc. I try to focus first on the local production of food before using fortification and supplementation. Therefore in health and nutrition, agricultural and nutritional technologies are much needed.

Apart from school children, we also work with day care centres, mother and childcare, pregnant women, and provide health education for these target groups.

We assess the progress of the project roughly by monitoring weight and height of the target groups, testing blood samples and calculating agricultural production and food intake in the area. There are many cases that nutrition projects have less favourable consequences. We have found out that the target groups have suffered from parasites. Some have severe diseases such as malaria and dengue fever.

ROLE OF SCIENCE AND TECHNOLOGY IN DEVELOPMENT

Over the past century we have witnessed the key role of science and technology in development leading to more production of food, better housing, better health and higher quality of life in most countries. Strong positive correlation between science and technology development and economic development has been confirmed in the World Competitiveness Yearbook published annually, the results of a long-term comparative study of about 60 countries by the Institute for Management Development (IMD). We can plot a graph of any science and technology capacity indicator, like R&D expenditure per capita, R&D personnel, IT users, patents, or publications against the GDP per capita, and find a consistent positive correlation between them.

There has been remarkable advancement of platform technologies like information technology, biotechnology, material science, nanotechnology and space technology. Once a high-capacity technology is discovered, there is always a need for commercial mass production to facilitate every household and every individual to have even more convenient living and working. In our lifetime, we have already witnessed an astonishing change of lifestyle and social interaction. Something that was considered very high-tech and very expensive at one time can later on be very cheap and affordable by all. Science and technology can also make that happen.

In the area of **information technology**, it was not so long ago when we had to punch a big bunch of cards to put our data into huge mainframe computers at the computing centres. Today we have the privilege of having much higher-capacity and many times smaller computers right in our own homes, or even in our palms, the ones that can connect us with sources of information and people all over the World. It is possible for us to see another revolution of information technology in the near future in the field of quantum information science. We can expect even faster communication, speedier processing of complex interactions, and unlimited access to countless sources of information.

Computers are used in every aspect of development work, for instance, building a database of each activity, controlling the machineries, bookkeeping and accounting, etc.

Let me give one example about the use of ICT in development work. There is a lot of work to do all over the country. I cannot be present everywhere in the country at the same time. I use e-mails or SMS successfully in communicating with my teams of development workers and in receiving their reports.

Robotics is also a result of the advancement in computer and electronics. We can design robots to replace human in risky tasks. We can also have robots to help out in many other situations.

In **biotechnology**, high speed sequencing of genes, genetic engineering, protein engineering and the convergence of science and engineering disciplines have opened up many new research possibilities, like stem cell research, tissue engineering, bio-imaging, cognitive science, molecular diagnostics, recombinant vaccines, differential drug delivery, and bioremediation, etc., leading to the discoveries of new products and processes that are useful in medical, agricultural and other industries.

As natural resources become scarce and there is increasing concern about environmental deterioration, **material science** has played its important role in developing environmentally friendly materials and low-cost artificial materials for different uses, including construction materials. New ceramic materials such as piezoelectric ceramics, bioceramics and electronic/ electro-optic ceramics provide technologically important alternatives to traditional ceramics. Special polymers can be used as artificial muscles and light-emitting devices. Equipments using solid-state ionic materials form the basis for new types of batteries, fuel cells and sensors.

In recent years, there seems to be a lot of natural calamities that give new challenge to development workers. We have to do planning to build completely new villages. New building materials are needed for houses, and infrastructures, for example, electricity, water supply, waste and wastewater management, road systems, etc. All should be environmentally friendly.

Nanotechnology has become promising when nanoscientists learn and know more about how to manipulate things at the atomic level. Nanotechnology Centre is a new centre in Thailand, and we cooperate with companies. The centre cooperates with the R&D departments of some companies. For example, we produce microchips for a European company that makes medical equipments, and the company helps us develop the products. Some of these products are used as sophisticated tools for development

Space science and remote sensing are also very advanced, and with the combination of information technology, we can now view the pictures of our roof and lawn or any place on earth in real time, right on a monitor in our own home or palm.

To be able to manage development, we need to know the terrain well enough before starting any project. That is the reason why survey engineering and cartography are very important. Apart from topographic maps, we used aerial photographs, airborne sensors and satellite images. Remotely sensed data has many applications. I myself used to do the classification of land use and land cover and used some information for some development projects. In the early '80s, the resolutions of the sensors were not as high as what we have nowadays. We benefited just from the electromagnetic spectrum and electronic signals. It depended more on ground truthing. Digital images can be integrated with other information in GIS, and it is a good tool for decision making in development.

SOME DEVELOPMENT PROJECTS IN THAILAND

This year the Thais celebrate His Majesty the King's 60^{th} anniversary of the accession to the throne. There have been more than 3,000 development projects during those 60 years. Some are called the Royal Projects specifically to help the Northern hill tribe people, originally to replace their opium plantation with other crops. Some are the King's Private Projects, to test his hypotheses or ideas before large-scale implementations. Most projects, in the order of thousands, are called the King-Initiated Projects, which may be under many governmental organizations and coordinated by the office of special commission to coordinate all of the King-Initiated Projects. I have been helping in some projects, and I would like to share some of them with you.

WATER RESOURCE DEVELOPMENT

His Majesty considered water resource development the main aim from the beginning, because water is the most important factor of agriculture.

1) Thai people are familiar with the pictures of His Majesty carrying the maps with him everywhere, in order to update maps of the project areas and then plan the irrigation projects to suit the needs of the people. Even with small scale topographic maps (1:50,000) he can tell the good sites to build dams, the amount of water in the reservoir, the size of the watershed, the nature of the ground (which kind of rock formation and soil) and even the cost of construction. I would like to show an example of a newly constructed underground dam in Chiang Mai. It was built in a cave. The advantages of building such a reservoir are that we have less water loss due to evaporation, and the water does not flood local farmland. The difficulties of the construction are due to the nature of karst formation (limestone area) that needs grouting. Careful geophysical survey should be done.

2) Seven models of Chaipattana aerator have been developed. The manufacturing and material costs vary between US$ 1,000-2,500 and the operating cost is around 1.5 unit of electricity/hour (at $0.05/unit). A Chaipattna aerator can deliver up to 2 kg. of oxygen per horsepower per hour into the water. It is now widely used to treat the water both in Bangkok and rural areas.

   The "Chaipattana Aerator" has been considered and received a patent in His Majesty the King's name on February 2, 1993. The aerator is the world's ninth mechanical aeration device to be patented and the first patent to be issued to a Monarch, and so His Majesty the King became "*the first Monarch in Thai and World history to receive a patent*". In terms of the international awards of honour, the Belgian Chamber of Inventor, which is Europe's oldest organization of invention, organized the Brussels Eureka 2000: the 49th Anniversary of the World Exhibition of Innovation, Research and New Technology between November 14-20, 2000 in Brussels, Belgium. The International Committee and the National Committee presented cup prizes, medals, and certificates to His Majesty for his sagacious invention of the "Chaipattana Aerator" as follows:

   - Minister J. Chabert Cup, which is the award for an outstanding invention presented by Minister of Economy of Brussels Capital Region

- Grand Prix International Cup, which is the award for the ingenuity in invention presented by International Council of the World Organization of Periodical Press
- Prix OMPI Femme Inventeur Brussels Eureka 2000 Medal together with certificate, which is the award for the world outstanding invention presented by World Organization of Intellectual Property
- Yugoslavia Cup, which is the award commending His Majesty's ingenuity presented by the Group of Yugoslavia countries
- Gold Medal with Mention and certificate, which is the award for the ingenuity of His Majesty in efficient application of the technology presented by Brussels Eureka 2000.

3) Cloud seeding for artificial rain or Royal Rain Project was initiated more than 50 years ago. The process is divided into three stages. Each involves flying on an aeroplane to spray different well-known and nature friendly chemical substances such as calcium chloride, ammonium nitrate, sodium chloride or kitchen salt, dry ice, silver iodide, etc. at the selected altitude and location where clouds are seeded. It turns into mass which becomes unbalanced and formed beads of water falling down as rain drops eventually. A high degree of expertise and experience is required in selecting the type and amount of chemicals to be used, while taking into consideration weather conditions, topographical conditions, wind direction and velocity, as well as the location or delimitation of the area for chemical seeding. Royal Rain Making is a true friend of farmers in time of droughts.

It can also be useful as a tool for environmental protection, because it can put out forest fire in some regions.

SOIL

The studies of soil quality, protection of soil erosion and soil conservation are important development issues in an agricultural country like Thailand. His Majesty initiated many ideas to correct different kinds of problematic soil, for example, saline soil, acid sulphate soil, nutrient deficient soil, sandy soil with hardpan, etc. The cause of each problem has to be carefully studied, and the problem is corrected accordingly. For example, for the acid sulphate soil, the cause is the sulphuric acid which is formed from sulphate-containing sediments through a natural process. So to correct it, we can either wash the acid off by flooding the area with water then draining it, or mix the soil with alkaline marl to neutralize the acid. A more drastic change can be done by speeding up the reaction of sulphuric acid formation, so that all sulphate is gone. Then the acid soil is treated once and for all. This is the so-called "the Land Aggravation Project", and all steps require scientific knowledge and scientific methods.

Vetiver grass is an amazing plant that, at first sight, looks like another kind of weed. Vetiver grass is very common in Thailand. It is fast growing and has a very deep and thick root system that spreads vertically rather than horizontally. When grown densely, the roots act like an underground wall or curtain to trap the soil from eroding and the moisture in the soil. It can endure harsh condition. His Majesty was first interested in this plant more than 10 years ago and started experimenting. Now it is proven that vetiver grass is the best plant to prevent soil erosion and to conserve water in the soil. It also has many other uses, for example, the leaves can be woven into nice handicrafts, and the roots of some species can be extracted to make perfume.

ENERGY

There are many projects on energy. At Chitralada Palace there is production of rice husk charcoal and gasohol. There are many ongoing research projects on alternative energy, for example, hydro-electricity, bio energy, solar energy and wind energy.

I am now responsible for a bio energy research project, as we all know that diesel oil can be extracted from coconut, palm fruits, jatropha seeds and even used cooking oil. It remains for an innovative economic model to be found. The market demand for edible oil produced from palm fruits and coconut is more competitive than energy oil. In this sense, it is believed that a community production for community use, instead of a large-scale production for nationwide use, is the most promising economic model at the current stage. A few pilot projects in different parts of Thailand are going on. It is expected that villagers in a small community can learn how to find the right balance between crops for food and crops for energy.

SCIENCE AND TECHNOLOGY FOR PEOPLE WITH DISABILITIES

Science and technology, especially the IT, are very useful for the independent living and the education of the people with disabilities. We have to take care of them case-by-case, because their defects and needs are mostly different.

Since 1975, I have been responsible for the welfare of the disabled war veterans, so I have become interested in the production of artificial prosthesis with the use of new material and IT, and robotic techniques. These science and technology help boost their quality of life, and so it is a part of human resource development.

There are some cases of congenital disability, for example, children without limbs. So computer with special parts like trackball and software for voice command are used. Computer-controlled wheelchairs are useful.

I have just started a new project to help the blind to study science. In Thailand there are about 600,000 blind people. Statistically, only some hundreds of them received university degrees, and all in social sciences and humanities. The general attitude of most people including the teachers is that the blind cannot study science, because it is too dangerous for them to do scientific experiments. We now have some bright blind kids in our pilot project, who are studying science courses just like other students in the science track, with the help of computer that works through mathematical models enabling them to do the calculation. So they can work just like sighted people. It is a great challenge for us to try, and with the help of many scientists and technologists I believe that Thai blind children will have good future like the blind in many other countries.

ICT, DISTANCE LEARNING AND E-LEARNING

In the Golden Jubilee Year of 1995 when we celebrated the 50th anniversary of His Majesty the King's accession to the throne, the Distance Learning Foundation (DLF) was inaugurated, and a distance education centre was established at Klai Kangwon School, Hua Hin District of Prachuap Khiri Khan Province. It uses both satellite and television, and later on the Internet, to reach out to all in remote schools. Nowadays the DLF has extended its services beyond its original objectives to also cover more than 3,000 ordinary schools, vocational and general education, public and private.

I use distance learning and e-learning to train teachers in the remote areas. In the future, hopefully, ICT will be able to create equal opportunity for all.

The IT training courses are also offered to prison inmates in order to give them opportunities to acquire knowledge and skills in the use of IT. Some also learn how to repair computers. Some can earn money from their IT skills while serving their terms. Our survey has shown that a number of them even got jobs in IT firms after they got out. The training program is now extended to cover prisons in provincial areas. An IT degree program is being discussed with a local university.

DATABASE

ICT enables us to have extensive databases of anything. It also helps linking the databases together. I have succeeded in establishing the database of plant genetic resources in Thailand, by bringing the dispersed databases under the same system and linking all of them up. This is not an easy task, but once it is done, it is very useful for researchers and students. I know that there are many worldwide scientific databases that scientists and technologists can share and contribute from all over the World. This is how science and technology advance.

GLOBALIZATION: OPPORTUNITIES AND CHALLENGES FOR SCIENCE AND TECHNOLOGY

It is now the age of globalization. The goal of our development work should be sustainable, integrated, holistic and balanced development. We live in a borderless world which offers us both opportunities and challenges.

OPPORTUNITIES

1) The world is shrinking while the information world is expanding. News from one corner of the world can be heard everywhere simultaneously. Science and technology have bridged the geographical gaps by bringing people closer together through faster communication and transportation. Linking databases and sharing them enable more self-learning of knowledge and information. Anyone can increase his or her knowledge with less dependence on experts. We become more self-reliant on updating ourselves to the advancement of knowledge and information.

2) Science and technology are no exception. They can reach more target groups nowadays, and open up more choices and opportunities to all. The trend will go on at an even more rapid rate.

CHALLENGES

Even though many opportunities are opened up for us, many new problems and dilemmas also arise. Those will be the challenges of this century.

1) The first challenge is how to have more people learn and keep up with rapidly advanced science and technology. Many more trainings are needed for more people to master new advanced technologies fast and well enough to make maximum uses of them.

2) The second challenge is how we can build up the capacity of our educational process to increase the abilities of our next generations to analyze, synthesize and evaluate, so that they are able to make good decisions to make better use of the enormous information and knowledge available to them.

3) The most important challenge is the ethical and social aspects of the science and technology application. How can legal and social institutions keep up quickly enough with the dynamism of science and technology, to understand their impacts on humans and societies and to protect them from unethical uses? We also have to think about how to take care of more waste products and toxic wastes of science and technology, besides wasting more money due to quickly outdated equipments.

4) The existing science and technology may result in an increase of the world population, so new challenges arise. The Earth is facing many crises, like energy and freshwater shortage and global climate change. Rises in the cost of crude oil have pushed government and private laboratories to develop cheaper sources of energy. The Worldwatch institute predicted that gas, solar energy, wind and geothermal energy would take a large share of the world energy market while the use of coal and oil would fall sharply in the near future. There is also concern about cleaner energy as well as clean freshwater. Although we are enjoying more convenient living and working brought about by science and technology, in this century we also have to

take care of many global problems, like energy shortage, freshwater scarceness, "greenhouse" gases and natural disasters. These too have to rely on science and technology.

There is no end when it comes to human capacity to discover new science and create higher-capacity technologies to meet our demands. Science and technology are definitely useful tools of development. Like any tool, however, it is double-edged, and so it can be harmful when misused. The question is how we can keep ourselves from becoming the victims of our own success.

In September 2002 the United Nations has adopted the Millennium Development Goals (MDGs), as a blueprint for building a better world in the 21st Century. The declaration of MDGs has marked a global commitment and concerns of less developed countries. The MDGs aims are to ensure that every child gets primary education, child and maternal mortality reduced, HIV/AIDS, malaria and other diseases under control, and the number of people living in extreme poverty and hunger to be halved, all by 2015. This is a big challenge for us all.

As the costs of technology and that of research are rising, "knowledge divide" in the growing "knowledge society" and "knowledge economy" can become a big global issue in the near future. We may be faced with more poverty, illiteracy, ethical problems and social unrest due to that "divide".

I believe that bringing young brains and great minds from all over the World to discuss these issues can help bridge the divide and steer the use of science and technology towards the MDGs.

EPILOGUE

Through a number of years of my development work, I have learned a great deal about science, technology in development. I can say that development, facilitated by science and technology, can really build up the capacities of people, regardless of their cultural, socioeconomic and religious backgrounds. Development workers just have to realize that development often takes time and a lot of efforts, but changes do occur. No matter how little those changes are, they occur and accumulate. The instant reward that development workers can have is the joy of learning, gaining more experience and helping others, the reward they can keep for themselves for the rest of their lives.

Once in 1990 while resting on a desert floor on my way along the Silk Road in Northwest China, a sea of countless sand that extended beyond my sight made me think of a person in search of science and technology to quench his or her thirst of knowledge and to find the ways to solve problems that mankind faces.

“Though a hundred years more I acquired
I would not have time enough
To roam the world as desired
I rush and run and rush and run
Even to my last breath
To see the world and the universe
My heart, with delight, opens wide
To savour all the truth
To love with all my soul
To learn and cherish my mind
I’ll verify my memories
To last a hundred eternities!”

Koji OMI

Member, House of Representatives, Japan

Koji Omi joined the Japan Ministry of International Trade and Industry (MITI) in 1956, and served in several key roles in Japan and abroad. He left MITI in 1982, and was first elected to the House of Representatives in 1983. Now serving his eighth term, he has occupied a number of prominent posts, including Parliamentary Vice-Minister for Finance; Chairman of the Standing Committee on Finance; Director-General of three Liberal Democratic Party (LDP) bureaus; and Acting Secretary-General, LDP. Mr. Omi has twice served in the Prime Minister's Cabinet: as Minister of State for Economic Planning (1997–1998) and Minister of State for Okinawa and Northern Territories Affairs and for Science and Technology Policy (2001–2002). A prominent figure in science and technology policy, he founded the Science and Technology in Society (STS) forum, which meets annually in Kyoto, with the aim of building a worldwide network among scientists, policy makers and business people. He is a graduate of Hitotsubashi University (Japan).

GLOBALIZATION AND THE KNOWLEDGE-BASED SOCIETY

In the era of globalization, Japan, a nation without abundant natural resources, can survive only by transforming itself into a knowledge-based society by promoting science and technology. To this end, the science and technology basic law was enacted in 1995. Based on this law, the government formulated five-year basic plans for promoting science and technology. One of the significant features of each basic plan is setting the target amount of governmental science and technology expenditure for five years. Other progress made during these plans includes strategic prioritization, collaboration between universities and industry and strengthening the intellectual property system. The 3rd basic plan started this year. Major points of the plan are: the target amount of governmental science and technology expenditure set at 25 trillion yen or 220 billion dollars; further strategic prioritization including five national core technologies; and system reforms to accelerate innovation. In addition, Japan will play a crucial role in tackling global issues such as global warming and infectious diseases. The STS Forum, held annually since its establishment in 2004, is a unique platform for expanding human networks to discuss and address such global issues. The Okinawa Institute of Science and Technology is another model that aims to make a notable contribution to the advancement of science and technology in the world. Japan should also strengthen cooperation with developing countries, since their engagement is the key to resolving global issues.

Goverdhan MEHTA

President, International Council for Science (ICSU)

Professor Mehta is a leading researcher in the area of chemical Sciences and presently CSIR Bhatnagar Fellow in India. He is an author of over 400 research papers in leading international journals and has delivered over 200 lectures in major conferences around the world. Previously, he has been the Director of the Indian Institute of Science (1998-2005) and the President (Vice Chancellor) of the University of Hyderabad (1994-1998), two of India's most prestigious academic institutions. He has been the President of the Indian National Science Academy (1999-2001) and founding Co-Chair of the Inter Academy Council (IAC, 2001-2006). He is Fellow of the Royal Society (FRS), Foreign Member of the Russian Academy of Sciences, Fellow of TWAS and recipient of over 30 medals/awards and numerous Honorary Doctorate degrees. Currently he is the President of the International Council for Science (ICSU).

SCIENCE AND TECHNOLOGY FOR A BETTER WORLD: RETUNING THE ROLE OF SCIENCE

Science &Technology for a Better World:
Retuning the role of science

Goverdhan Mehta, President
International Council for Science (ICSU)
and Indian Institute of Science, India

Structure of the presentation

- The 'unfettered' march of science
- Rejuvenating science – a new age
- Science and Society- plea for 'cohabitation'
- Imperatives of 'policy' in an asymmetric world
- Science as a world system - Intl. dimension
- ICSU striving towards a better future for all

A panacea for everything

The Dawn of Knowledge Era

- Spectacular developments in science and technology
- Unparalleled economic growth –
  globalization, competition, innovation at the vanguard
- Uncontrolled exploitation of earth's resources

21st century will be the century of knowledge

....the process of transition is on

The pivotal role of S & T.....

"The 20th century's unprecedented gains in advancing human development, industrial growth and eradication of poverty in certain regions of the world came largely from technological breakthroughs"

In the 21st century, this role needs to be recalibrated

Why?

Progress in science has been for most part, insular, monolithic and unitary

and at an unprecedented pace.........

Science has grown exponentially at a rate of about 7 per cent per annum, doubling every 10 - 15 years, growing by a factor of ten at every half-century, and by a factor of a close to a million in the past 300 years.

cf. Societal evolution domain is ~ 10,000 years

Relentless pace of technology

Shrinking time domains

Faraday	1830	→	1881	Electricity
Watson-Crick	1953	→	1973	Genetic Engg.
Iijima (CNT)	1991	→	2001	Logic circuit

More new information has been generated in the last 30 years than in the previous 5000

Scientific revolution has outpaced social revolution for over a century now

As a consequence of this disconnect…..

…….the burning issues confronting the world today relating to environment, energy, health, natural hazards, extinctions, unsustainable consumption and most importantly of growing inequalities and knowledge divide, did not come into sharper focus soon enough…..

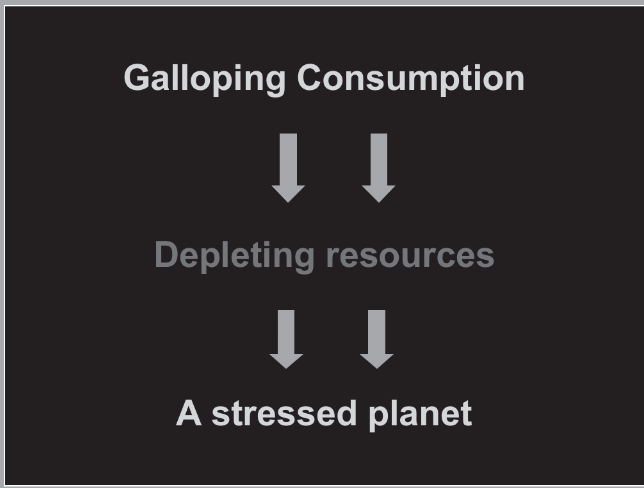
The Paradox of Our Time

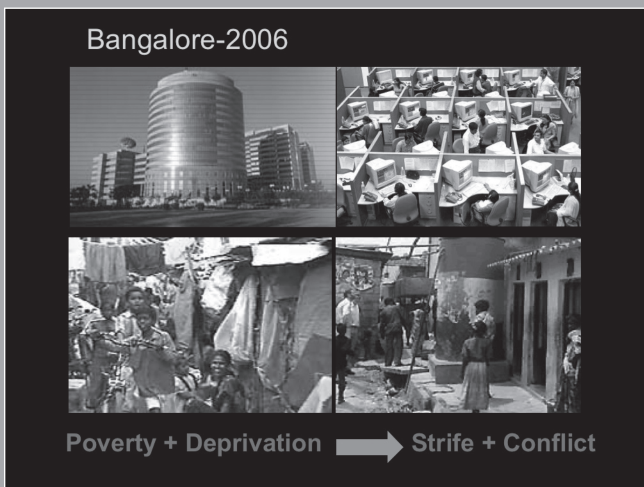
Despite spectacular advances in science and technology, unprecedented economic progress and improvement in the quality of life…..

Growing inequalities

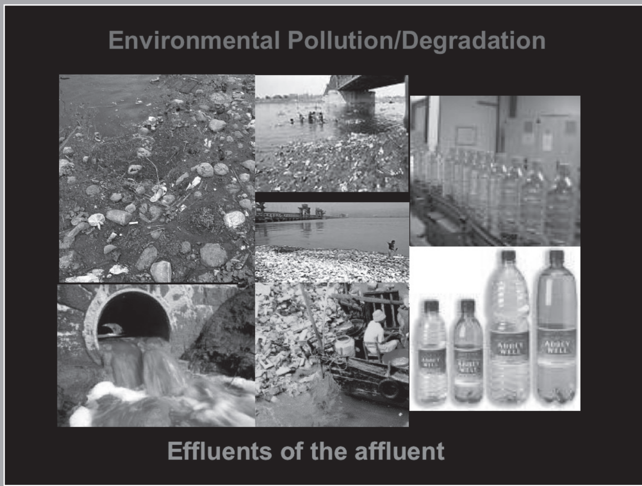
Knowledge Divide

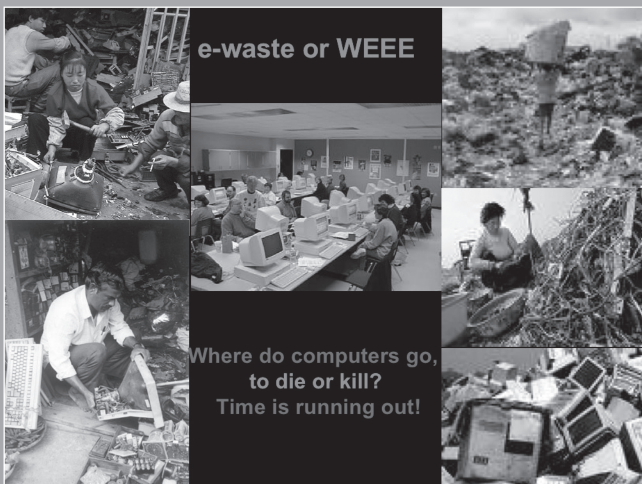
A troubled world


Galloping Consumption
Depleting resources
A stressed planet


Bangalore-2006
Poverty + Deprivation
Strife + Conflict


Environmental Pollution/Degradation
Over consumption
'Un-sustainability'

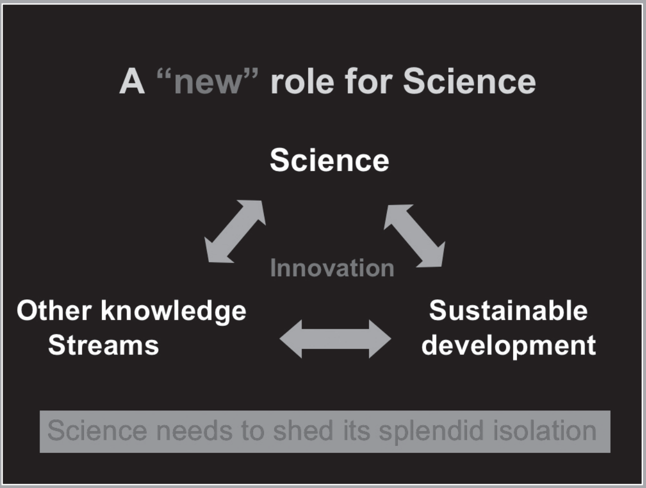


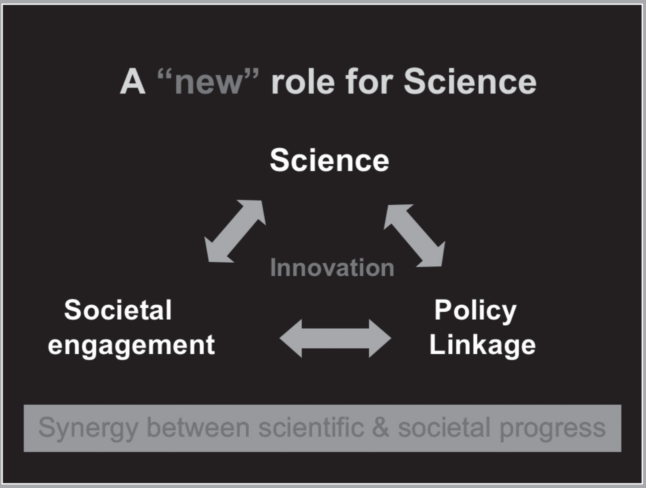


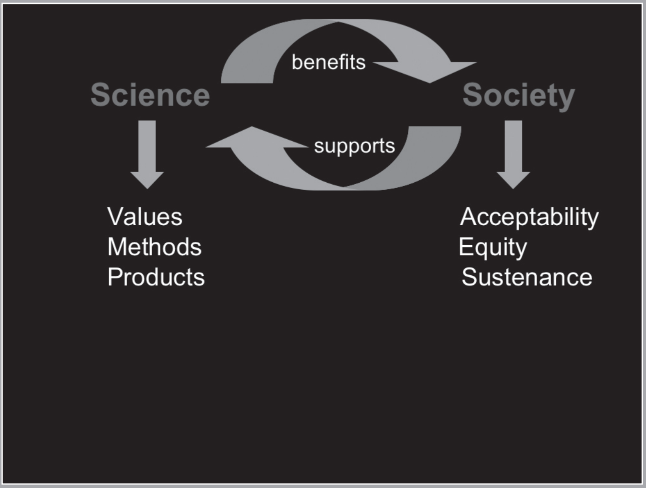
What can science do ?

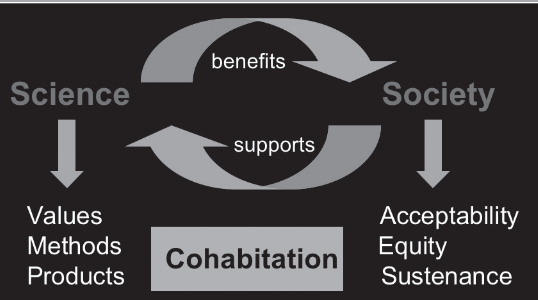
In the 21st century, a more inclusive view of science

'..conception that science is autonomous is unsustainable.'


A "new" role for Science
Science
Innovation
Other knowledge Streams
Sustainable development
Science needs to shed its splendid isolation


A "new" role for Science
Science
Innovation
Societal engagement
Policy Linkage
Synergy between scientific & societal progress


benefits
Science
Society
supports
Values
Methods
Products
Acceptability
Equity
Sustenance



Science – Responsible, transparent, and understand the full implications of new discoveries in the context of moral and ethical values and sustainability of our planet

Society – Must shed its cynicism and skepticism about science and recognize its centrality for human good

'....To assume one basis for life and a different basis for science is *a priori* a falsehood....Natural science will in time incorporate into itself the science of man, just as the science of man will incorporate into itself natural science; there will be one science'

- Karl Marx

Scientists must ponder over their inability to transfer the sense of objectivity and responsibility that they so effectively deploy in scientific experiments and search for truth to the other side, namely society's evolution.

The focus in the new age science…

Beyond discovery :
addressing human needs and concerns

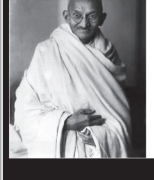
Great opportunities……

Connecting to UN 'Millennium Development Goals'
eg. hunger, health, education, environment
Linkages with Global Change Research Programs
eg. climate change, energy issues

What is the way forward……?

Centrality of societal engagement, policy interventions, and international partnerships

"Policy, not charity, will determine whether new technologies become a tool for human development everywhere" …. and for all



There is enough on this earth for everyone's needs but not for everyone's greed

- Mahatma Gandhi

UNDP-HDR 2001

"There is hardly any social problem on which science cannot make some contribution"
-D. K. Price, Scientific Estate

Science for policy
and
Policy for Science

Science is never sufficient to solve a problem completely; it is, however, always necessary.

The challenge of poverty.......

" The market is a powerful engine of technological progress, but it is not powerful enough to create and diffuse the technologies needed to eradicate poverty"

'Policy interventions backed by political will and commitment can make a vital difference'

UNHD Report 2001

The reality......

'political will in a globalizing world is focused on security than on development; stronger in finance and trade than in environment…'

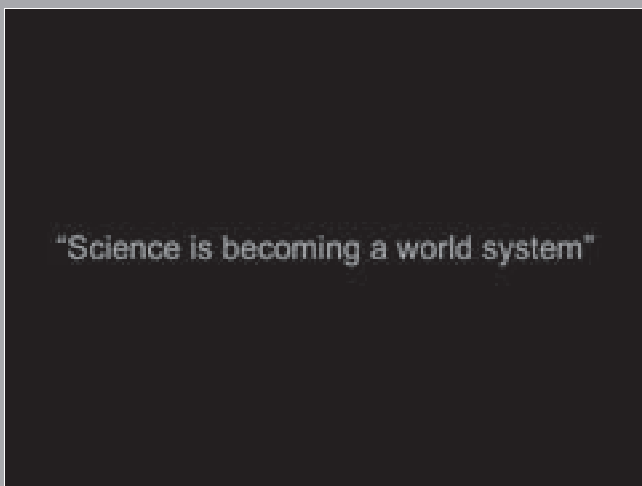
The need …

…..address causes not consequences

For that……

…a political leadership that is scientifically informed and scientific leadership that is politically savvy is required…..


A peaceful planet
Sustainable Development
An inclusive world
Eradicate poverty
Secure environment
Science + Society + Policy


"Science is becoming a world system"

Hama Arba DIALLO

Executive Secretary, United Nations Convention
to Combat Desertification (UNCCD)

Before joining UNCCD, Hama Arba Diallo was Special Representative of the Secretary General of the United Nations Conference on Environment and Development (UNCED). He previously served 24 years as a top official in the state and foreign ministries of Burkina Faso, including as Minister of Foreign Affairs and Ambassador of Burkina Faso to China, India, and Japan. A specialist in African economic development and environmental issues, he was long involved in the United Nations Development Programme (UNDP), and from 1979 to 1983 served as Deputy Director of the United Nations Sudano-Sahelian Office in New York, operating under the UNDP. From 1966 to 1976, Mr. Diallo served as a delegate to the UN General Assembly as well as to other UN agencies.

SCIENCE, TECHNOLOGY, AND ENVIRONMENTAL CHALLENGES

All of us here today agree that science and technology is a major driver of globalization. It is happening, and most of us believe that it is unstoppable. Many of us see the type of science and technology that drive globalization as helping to cure a multitude of the world's ills.

To those of us working to combat desertification and land degradation, "globalization" refers to the compression of the world and the tightening of all the linkages - economic, political, social, environmental - between developments here and events in far comers of the world. Every country feels the reverberation of globalization. It is a process of integrating not just economies, but also cultures and environment.

A decade before the word 'globalization' became fashionable in the late 1980's the environmental community both in and out of government was realizing that environmental problems were becoming increasingly trans-boundary in nature and were reaching global-scale proportions. The early 1980s saw the emergence of an international environmental agenda, and what has taken place over the past two decades in response to that agenda can be thought of as the first attempt at global environmental governance. Perhaps the only concept as heavily laden with multiple agendas as "globalization" is the concept of "sustainable development". In many respects the paradigm of sustainable development was the international community's first attempt at global environmental governance. It is important to note what has been accomplished to date in the area of global environmental governance and this may help us find our way in the discussions on policy at this conference.

There are **seven principal environmental activities** that have taken place over the past twenty years.

First, several international conferences, negotiations, action plans, treaties, and other initiatives to promote sustainable development have occurred. New fields of international environmental law and diplomacy have been born. There are now over 250 international environmental treaties, two thirds of them signed in recent decades.

Second, there has been a vast outpouring of impressive and relevant scientific research and policy analysis.

Third, an ever-stronger community of intergovernmental and nongovernmental organizations has launched increasingly sophisticated campaigns.

Fourth, governments as well as multilateral institutions from the United Nations to the international development banks have recognized these concerns and have created major units to address global-scale issues.

Fifth, many multinational corporations have moved ahead with impressive steps, often ahead of their governments.

Sixth, in academia, international environmental affairs have become a major subject of academic inquiry and teaching.

And seventh, the United Nations has sponsored an extraordinary series of milestone Events beginning with the 1972 Stockholm Conference on the Human Environment that was followed by the 1992 Rio Earth Summit and the 2002 World Summit for Sustainable Development in Johannesburg.

How should we assess the progress of the last two decades during which we have been aware of extraordinary global environmental challenges? Progress has been made on some fronts, but not nearly enough. There are outstanding success stories, but rarely are they scaled up to the point that they are commensurate with the problem. For the most part, we have analyzed, debated, and negotiated these issues at length. We now need to translate all the good will into actions. How should we grade the international community's responses to the global-scale environmental challenges? And how can globalization deliver science and technology in such a way as to address the environmental challenges?

The three Conventions on desertification, climate, and biodiversity –coming out of Rio have called attention to the problems and have led to action programmes in the three areas. For various reasons these agreements are not yet fully implemented. For instance the priority activities under the action programmes to combat desertification have just started and the Kyoto Protocol is the first significant step beyond the Framework Convention on Climate Change. These actions represent only a modest down payment on what is needed.

The principal response of the international community to global scale environmental challenges to date has been a legal one, often regulatory in nature. Other avenues have been pursued, such as somewhat increased government spending on these issues, and mechanism such as the Global Environmental Facility.

In my view, the approach taken to global environmental governance should give due consideration to technology transfer that might address underlying causes. The UNCCD has contributed to this effort through the establishment of a Committee on Science and Technology and the definition of specific guiding principles on technical and scientific cooperation.

At a time when the international community is celebrating the United Nations International Year of Deserts and Desertification, it is important to emphasize the critical role of science and technology in achieving the expected goals of the UNCCD.

Today the transition to a globalized world is progressing rapidly, but the transition to a sustainable one is not. Some believe that globalization is a prime reason for the failure to realize sustainable development. But many of us here today will argue that globalization can and should advance the transition to sustainability.

One of the points I would like to make this morning is that the globalization of markets, driven to a degree by science and technology, has brought about a globalization of the environmental problems. Global warming, the loss of biodiversity, the depletion of natural resources, and widespread deforestation and desertification are examples of global environmental deterioration that have emerged and worsened while the process of globalization has accelerated. Generally speaking, technology and science have exploited natural resources. History shows us that new waves of technological innovation have raised new environmental problems along with new opportunities for solving them.

In my view there are three types of environmental challenges, which confront globalization and sustainability:

The first one deals with shared problems involving the global commons, that is, fundamental elements of the ecosystem – among the most significant challenges, in my view, are desertification with its loss of topsoil, and of course climate change.

A second category of global environmental problems involves the interlinked challenges of demographic dynamic and resource consumption – pressing examples under this heading include mass human migration, and threats to the existence of certain species.

A third category of problems is trans-boundary pollution such as acid rain, or river pollutants, or contaminated rain.

At the core of any policy discussion on globalization and environmental challenges is the long-term correlation between these three categories of problems and the modem process of globalization of international markets and environmental degradation.

We are at the early stages of the journey to sustainability. The sustainable development paradigm incorporates the following: the needs of all countries, big and small alike; a commitment from the strong to help the weak; a concern with both environment and development; and a realization that the state and the international community must intervene on behalf of public interest to attain greater social equity and bring about more sustainable patterns of production and consumption.

Globalization should not destroy the environment. In some instances however, increased international trade appears to harm the environment. When business activity is increased in a generally unsustainable way it tends to spoil the environment.

In my view a focus of this conference should be on the contrary force, which can be developed through science and technology – there is a set of factors that suggests that globalization may help environmental quality. Multinational corporations can spread the most advanced environmental management technology and techniques. The strengthening of capacities in government to manage economic affairs can have spill over effects, strengthening environmental management.

Globalization can lead to increased incomes, which in turn can lead to governmental revenues for environmental and social programs and to increased public demand for environmental amenity.

Scientists are a cautious lot, by and large, so when the most respected issue a plea for "active management of the planet," we must take notice. Today we are moving rapidly to a swift and appalling deterioration of our environmental assets particularly in our soil resources. There is still world enough and time enough, but the decades immediately ahead are crucial. The next doublings of the world economy cannot resemble those of the past. Governments must bring a new toughness to international environmental law and complement it with serious efforts both to address more directly the underlying drivers of environmental deterioration and to improve dramatically the overall economic and political context that determines whether legal regimes surrounding globalization are meaningful or weak and whether they succeed or fail.

On the environment front, there should be a matching of the WTO with the collective global environmental mechanisms. The push for liberalized trade and investment flows should be complemented by equally concerted efforts on the environmental and social fronts. This should be one thrust of our policy recommendations from this conference.

Globalization is a multifaceted phenomenon with potentially devastating but also potentially beneficial consequences. Environmental NGOs have been particularly afraid – and not without reason –of globalization in its one-sided economic aspect.

It is possible to reinforce the positive effects and reduce at the same time the negative effects of globalization on the environment through appropriate policies meant to implement a robust process of sustainable globalization. What is important to discuss at this forum is how to use science and technology to address environmental challenges in a sustainable development context. Not an easy task, but it makes for a rich discussion, especially when one introduces the concept of sustainable livelihoods, alleviating poverty and emerging topics such as the dramatic loss of fertile top soil, mass migration of peoples and the global problem of youth unemployment.

It is easy to talk about the greening of economic globalization but tremendously difficult to accomplish. No amount of science and technology can free societies from the enchantment of limitless material expansion. The late John Kenneth Galbraith has called this the "highly contrived consumption of an infinite variety of goods and services." Global-scale environmental problems cannot be blamed only on big corporations when lifestyles, mismanagement by governments, North and South, and other factors are clearly implicated. Increasingly, pollution and other problems come not from something going wrong but from normal life.

Sustainability is the imperative that pushes the environmental agenda. The desire for a rich quality of life, strong human ties, and a resonant connection to nature is the lure that pulls us toward the future.

Whatever globalization's environmental consequences in the past, the future holds much room for improvement. There are a great many things that science and technology can deliver and should deliver in order to green globalization and give it a human face.

Realizing this brighter future will require heightened international cooperation, particularly between industrial and developing countries, but also among developing countries. We, therefore, welcome current initiatives to revive the commodity trade in the poorest of economies. But these initiatives are too limited. They will succeed only in expanding unsustainable and inequitable patterns of growth unless they are complemented by powerful initiatives to promote social equity and to protect the environment. Indeed, there is much reason to believe, based on past experience and current trends, that unless major complementary initiatives are undertaken to bring environmental, economic, and social objectives together, liberalizing trade and reviving growth could lead to short-term gains and long-term disaster.

We live on an active planet. Earthquakes are continuous, a million and a half of them occur every year. Our friends here in Japan are well aware of this frequency. A Richter 5 quake happens every six hours, a major quake every 3 weeks, a destructive quake every 8 months. It's nothing new; it's right on schedule. At any moment there are 1500 electrical storms on the planet. A tornado touches down every six hours. We have ninety hurricanes a year, or one every four days. Again, right on schedule. Violent, disruptive, chaotic environmental activity is a constant feature of our globe. This is our world. This is our environment. It's time we knew it and responded to the challenges it presents to us.

PANEL DISCUSSION: GLOBALIZATION, NEW TECHNOLOGIES, AND SOCIETY

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SCIENTIFIC AND TECHNICAL COOPERATION

GLOBALIZATION BY WHOM, FOR WHOM

Globalization is a powerful change mechanism without clear definition, explicit objectives or an agreed operational framework. Yet while complex and disorderly, it is increasingly clear that nothing about globalization is arbitrary because the changes it produces are the results of commercial, political and economic drives. It is also difficult to predict the future course of globalization, however some trends seem apparent: the pace of globalization is clearly accelerating with a continuous 'free' flow of information, investment capital, ideas, products and services between countries.

A fundamental challenge posed by global markets is that they are inherently disequalizing,[1] which means that they make rising inequality more likely rather than less. And yet accessing and participating in the global economy has become one major factor influencing the development process of individual countries. Therefore, considering globalization just as a threat or a problem has particularly negative consequences for developing countries. The big challenge for these countries is not to be swallowed up by the globalization process but to seize the opportunities it may open for the benefit of their own development and avoid as much as possible its risks.

One of the forces that push globalization is technological development. Science-based technological advance has also been a long-term driving force for modern economic growth[2]. Traditionally, in the high-income countries technological development has been enabled by the national setting: institutions, investment, regulations, academics, social/cultural priorities. Increasingly, however, such development is driven by factors beyond the national setting – the 'global economy'.

Yet the technological opportunities offered by the global market cannot be equally seized by developing countries. Technological innovations are increasingly created in response to market pressures and not the needs of the poor populations in those countries, where more than four billion people live on less than three dollars a day and face basic subsistence problems. The global marketplace is driven by the investments and consumption patterns of the affluent societies and therefore technologies are more often than not created to make life ever more comfortable and convenient for those who are not worrying about their next meal or wondering how to get medical care; this stock of technologies is not geared to provide the best solutions to development constraints.

TECHNICAL COOPERATION FOR DEVELOPMENT

Increasingly, scientific and technological cooperation have become pieces of the global machinery and have come to play an important role in bridging between the different parts of this still fragmented world. Here we have at hand powerful tools to support national development strategies and link them with global development goals.

For a number of decades, the conventional approach to cooperation for development had been to adapt technologies, often driven by the convenience of their owners or their promoters, to specific needs in developing countries. However, it is now recognized that this transfer of technology has not been effective for overcoming critical ecological barriers to development such as Malaria, Chagas and Trypanosomosis,[2] nor, say, for developing a sustainable and efficient use of the natural resources, with which many of these countries are generously endowed. Simple access to technology does not automatically mean that sustainable and desirable solutions can be adopted and adapted to local conditions or that they will lead to expanded technological capability.

Therefore, developing countries need to adopt comprehensive technology development strategies in their national development processes, including the respective policy, process and legal frameworks. The analysis underpinning such strategies should identify which technologies are critical for the immediate and longer-term future, what technologies are most likely to become obsolete or be replaced and what trends in technological innovation may influence technology development.

The primary function of such strategies is to help meet the requirements of national goals and priorities as identified by the countries themselves, furthering endogenous technological innovation and production; but they should at the same time strengthen the capacity of these countries to fully participate in the definition of global development policies and strategies in order for the latter to be of truly global benefit.

These decades of experience have brought about important changes in the approach to cooperation for development. Interestingly, there is a trend in the development community towards increased national focus, taking into account specific country conditions.

A major indicator in this regard is the Paris Declaration on Aid Effectiveness[3] which reflects a new consensus on international development that calls for strengthened partnerships with developing countries based upon defined national development strategies reflecting the specific needs, interests and priorities of each partner country. This consensus is reflected as well in the new EU Strategy for Africa,[4] which proposes the establishment of an EU-African Partnership for Infrastructure to support and initiate programmes, and trans-African networks that facilitate interconnectivity at the continental level for the promotion of regional integration. Strong national scientific and technological institutions in the regions are expected to play a decisive role in achieving the EU goal of helping to build an environmentally sustainable future for Africa.

Ownership is being adopted as a fundamental principle for international cooperation because it is widely understood that development policies and strategies cannot be imposed from the outside. For example, the vision of good governance, respect for human rights, gender equality and empowerment of civil society, embraced by the African Union and NEPAD, are now at the centre of EU commitment to Africa and will likely guide cooperation with other regions. However, the consensus on ownership does not yet incorporate a robust understanding that sustainable solutions to development problems and opportunities must be owned by the countries facing the challenges. It is not sufficient for developing countries to state their needs and formulate their requests; they must have the capabilities and infrastructure to advocate, analyze, postulate, test, validate, and adapt solutions to meet their unique and specific circumstances.

The new cornerstone strategies for international development must recognize that unique and differentiated circumstances determine the choices available to developing countries for advancement and participation in the globalized marketplace. They must also recognize the critical importance of institutional capacity development, including national scientific and technical capacities that enable developing countries to utilize the resources and participate in the benefits of economic integration. Given these new initiatives and the opportunities for more effective cooperation, it is of course imperative that developing countries, in their turn, recognize the importance of sound and sustainable national scientific and technological institutions and of the civil and administrative reforms that ensure advantageous and stable environments for sustained and successful efforts by their own scientific-technological communities.

THE UN SYSTEM AND SCIENTIFIC COOPERATION

The UN has an important role to play in helping developing countries meet the challenges of science-based technological development in the era of globalization. The Secretary General's Council of Development Advisors reported in March 2005, that the UN risks being relegated to the sidelines, in part because most UN agencies and programs are not set up to systematically receive scientific advice or use research as a key component of effective programming. The Panel[5] speculated that it is not the size or complexity of the UN that is the overriding challenge; its weakness lies in how it uses scientific and technical knowledge. Thus, its influence and effectiveness will increasingly depend on the extent to which the UN System can mobilize scientific and technical expertise to face 21st century challenges, such as infectious diseases, environmental degradation, exhaustion of natural resources, and other problems that in the past would have been the concern of individual nations, but have now grown to international importance, such as those embodied in the Millennium Development Goals.

The Panel considers that the UN's capacity to deal with these questions must grow. It also recommends that the UN system should increasingly engage the growing community of science and technology advisors. National bodies that provide scientific advice do not have an effective focal point in the UN system; neither do international organizations that catalyze research cooperation and technological innovation to address global development problems. The UN's ability to convene states and civil society should place international scientific cooperation at the forefront to provide fora for global consensus building based on scientific knowledge. As we have learned from the experience with the Kyoto Protocol and other specific cases, the UN system must also increase its capacity to engage the international community in the implementation of the recommendations arising from such fora.

International scientific cooperation has in fact a long history, longer than the UN system itself. Globalization as meaning 'disappearance of borders' and increased interaction between countries is an old phenomenon in science, first in the European and increasingly in the broader domain. Steps to bring together the international scientific community under a single organization date back to the late 19th century, and culminated with the establishment of the International Council for Science (ICSU) in 1931. It is ICSU's goal to ensure that science is integrated into policy development at the international and national levels and that relevant policies take into account both scientific knowledge and the needs of science. Through its membership of 29 international scientific unions and over a hundred national scientific organizations, ICSU brings together a unique pool of intellectual resources, backed by institutions all over the world. Some major interdisciplinary programmes created by ICSU are cosponsored by UN agencies and nongovernmental partners, such as the International Geophysical Year in 1957-58, the World Climate Research Programme, the Global Earth Observation System and, more recently, the International Polar Year 2007-08.

Recent trends, including accelerated globalization but also importantly regionalization (as occurring diversely in Europe and in Africa) have urged ICSU to review its policies and procedures, and one significant move in this respect has been the creation of regional offices in the major areas of the developing world. This recognizes that science cannot be international without the active involvement of scientists from all parts of the world in the scientific endeavour and in setting the research agendas, and also that international cooperation plays a key role in support of the national efforts of countries to build and put to good use their scientific capacity.

For similar reasons, other nongovernmental science-based organizations have been created more recently, such as global and regional networks of national academies of science, which play complementary roles and altogether provide a strong basis of support to the UN system on science-policy matters.

Globalization has meant also increased mobility of students, researchers and the scientific technological labour force, with a concomitant loss of stability in the workplace and job security. The job market for scientists has become highly competitive, even more so as public research loses ground vis-à-vis R&D funded by the (borderless) private sector. This makes it more difficult for developing country institutions to retain their best scientists and develop strong national S&T infrastructures.

The Millennium Project Report compares high-income countries that make public investments in higher education and in scientific and technological capacities, with poor countries that have largely been spectators, or at best users of the technological advances produced in the high-income world. Those countries often lack even medium size scientific communities, and their scientists are chronically under funded and nationally unmotivated, with the best and brightest often moving abroad to find colleagues and support for scientific research.

The incapacity of many developing countries to retain scientific and technical expertise has indeed become critical. The UN Economic Commission for Africa and the International Organization for Migration (IOM) estimate that 27,000 Africans left the continent for industrialized countries between 1960 and 1975. During the period 1975 to 1984, the figure rose to 40,000. It is estimated that since 1990 at least 20,000 people leave the continent annually, leaving sub-Saharan Africa with only 18 scientists and engineers per million population, compared with 69 in South Asia, 76 in the Middle East, 273 in Latin America, and 903 in East Asia (World Bank 2004). Africa as a whole counts only 20,000 scientists (3.6% of the world total) and its share in the world's scientific output has fallen from 0.5% to 0.3% as it continues to suffer the brain drain of scientists, engineers and technologists.

International and regional cooperation strategies and mechanisms are needed to counteract this negative influence of globalization and effectively support national R&D infrastructures. NEPAD has called for the establishment of a reliable continental database to determine the magnitude of the problem of brain drain and promote collaboration between Africans abroad and those at home. Recognizing the urgent need to develop Africa's human resource base, African leaders explicitly call for the creation of the "necessary political, social and economic conditions that would serve as incentives to curb the brain drain…"

Other regions of the developing world could also benefit highly from increased regional integration and cooperation in the scientific domain, not just to curb the brain drain but to address common problems and find joint solutions. Support by the international community and the UN system to specific regional cooperation mechanisms such as large experimental facilities, databases of centres of reference, joint educational programmes, or regional S&T observatories, would be a timely contribution to complement national efforts for the development of autonomous S&T systems.

Notes

1. N. Birdsall, Rising Inequality in the New Global Economy. WIDER Angle (UNU-WIDER), 2/2005, pp. 1-3.
2. Investing in Development. Millennium Project Report to the UN Secretary-General. Earthscan, London, 2005.
3. Paris Declaration on Aid Effectiveness. High Level Forum, Paris, March 2005.
4. EU Strategy for Africa: Towards a Euro-African pact to accelerate Africa's development. Commission of the European Communities, 2006.
5. Secretary General's Council of Development Advisors Report, UN, New York, March 2005.

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GLOBALIZATION, SCIENCE AND TECHNOLOGY: CHALLENGES AND OPPORTUNITIES FOR SUB-SAHARAN AFRICA

INTRODUCTION

We start with a short presentation of the state of science in Sub-Saharan Africa excluding Sub-Africa which is quite different from other countries in the region. The second section is devoted to some propositions which can help Sub-Saharan African countries benefit from globalization in the domain of science and technology.

SCIENCE AND TECHNOLOGY IN SUB-SAHARAN AFRICA

According to the European Organization for Cooperation and Development, one can distinguish three phases in the study globalization: internalisation which starts from the second part of the nineteenth century, transnationalization which begins with the end of the second world war and globalization which has followed the dislocation of the soviet block.

The historic snapshot presented here concerns Sub-Saharan Africa excluding South Africa. It is done following the three phases identified by Waast[7] and which can be put in parallel with the globalization phases as follows:

- internationalization and colonial science (. – 1960);
- transnationalization and the development of national science policies (1960 - 1980);
- globalization and free market for scientific work.

COLONIAL SCIENCE

As explained by Mve Ondo[4], colonial science "participated in the legitimation of the imperial and colonial enterprise. There were the early beginnings of the globalization of science, the primary objective of which was not one of sharing, but of serving the interests of the colonial powers. For the colonialist, it was not a question of organizing and sharing knowledge, but of occupying and exploiting conquered lands: mapping out of new territories, drawing up an inventory of natural resources, studying and controlling tropical diseases, a better understanding of the colonized populations and their cultures in order to make it easier to control them".

In this period, there was no local preoccupation for technology development. It was understood that technology was produced in the North and Africa was just a consumption field. This scheme is similar to the flow of exchanges where raw materials are extracted in Africa, processed in Europe and manufactured products are sent back to Africa. This phase has resulted in considerable realizations in the domain of science:

- organization: creation of research institutes employing full-time researchers; these institutes were decentralized in British colonies, whereas in French colonies, coordination was ensured by agencies such as ORSTOM and CIRAD;
- strategic choices: priority was given to agriculture and health;
- results and impact: very important results were obtained with a real impact on areas such as food production, tropical diseases eradication and oral literature.

Let us note that this period which corresponds to increasing liberalization of exchanges is also marked by the reinforcement of legislations for the restriction of migratory movements after the first world war. This shows that globalization is not a natural process but is rather the result of political and economic strategies aiming at attaining some predefined objectives.

NATIONAL SCIENCE

This period starts in the 1960's with the independence of African countries. Governments make strong policy statements in favour of science and technology as a foundation for socio economic development. This period is market by:

- africanization of research staff;
- nationalization of research agencies;
- development of university institutions.

Unfortunately, there was no effort on concept production or re-contextualization. In French speaking Africa, great emphasis was put on cultural identities and "negritude" even proclaimed that "emotion is Negro and science is Hellenic".

FREE MARKET FOR SCIENTIFIC WORK

This period starts in the 1980's with the structural adjustment plans imposed by the International Monetary Fund. It is characterized by:

- The declaration of IMF and other stakeholders saying that scientific research and higher education are not priority sectors for Africa;
- the decrease of budgets devoted to science and technology. In some countries some research institutes were even closed;

- salary cut and freezing of recruitment of research staff.

Curiously, governments which had invested huge amount of money in science and technological institutions as we have seen earlier, could have tried to use science and technology as a tool to solve the economic crisis. Unfortunately, they rather accepted without great resistance the theory developed by multilateral stakeholders and which was simply the renunciation of science.

The consequence on human resources was dramatic, as researchers were obliged to look for individual survival solutions:

- most of the young scholars educated in science and technology in western countries do not come back to their home countries.
- science and technology staff tend to migrate from Africa to Europe and North America, looking not only for better salaries but also better working conditions;
- topics tackled by researchers are dictated not by local needs but by foreign donors.

HOW TO PREPARE FOR A BETTER FUTURE

Rather than going through a catalogue of measures already available in excellent reports published among others by UNESCO and UNU, I will rather insist on some aspects chosen according to my personal experience.

GIVE MORE CHANCE TO SCIENCE AND TECHNOLOGY ORGANIZATIONS

The United Nations Educational, Scientific and Cultural organization[5] (UNESCO) covers the wide range of science and culture, and operated at all levels of the education. The United Nations University[6] (UNU) is a worldwide network pursuing through its programmes of knowledge generation, knowledge transfer and capacity development. The "Agence Universitaire de la Francophonie"[3] (AUF) and Association of Commonwealth Universities[1] (ACU), are two institutions which involve hundreds of French and English speaking universities respectively, and whose cooperation programmes cover a large range of domains.

The Academy of Science for the Developing World (TWAS) too, is an autonomous international organization with more than 700 members from 81 countries that promotes scientific capacity and excellence in the South. The initiatives undertaken by the Bill Gates foundation and other similar organizations must also be encouraged.

REAL APPROPRIATION OF SCIENTIFIC CONCEPTS IN BASIC AND SECONDARY EDUCATION

I am afraid that, when you question some university students on the meaning of the mathematical expression "4 times 5", ninety percent of them will say that "4 times 5" means four five times". The same can be observed of other fundamental scientific notions which have not really been mastered by students and cannot therefore be applied correctly.

STRENGTHENING SELF CONFIDENCE BY PROGRESSIVE TRANSITION

When solving a problem, the adoption from the outset of the most sophisticated solution is not efficient and may even lead to technological oppression. For instance, e-learning in Africa may not prevent the development of education by radio communication and mobile telephone forums, whose tools are already owned by most Africans, even in rural areas. In the same way, CISCO academies funded by the Japanese TICAD initiative which combine e-learning and the presence of local instructors are more efficient than 100% on-line curricula.

BRIDGING SCIENCE AND TECHNOLOGY, TECHNOLOGY AND INNOVATION, IDEAS AND POLICIES

The scientific and technological knowledge already mastered by African countries is not fully converted into development activities. In the same way, there is a confusion between good ideas and the elaboration of efficient policies. Very important initiatives have been done in this area by the Global Development Network (GDN).

GLOBALIZATION MUST NOT DESTROY WORLD DIVERSITY

Diversity gives a chance to everyone to seek specific knowledge for the solution of local problems, while benefiting from the global knowledge developed worldwide. In this way, science and technology will not be an oppression tool owned by those who can develop sophisticated technologies. Automobile industry is a very good example, where local research is necessary to conceive cars adapted to local conditions. Even when the technology is used uniformly, local contexts must be taken into account as can be seen from the success of the Digital Campuses of AUF, in comparison with the problems encountered by the African Virtual University

IMPROVING COOPERATION PROGRAMMES

We provide here as an example, the 11 principles proposed by the Swiss Commission for Research Partnership with Developing Countries[2] (KFPE). Members of the research partnership between industrialised and developing countries may: "decide on objectives together – build up mutual trust – share information, develop networks – share responsibility – create transparency – monitor and evaluate the collaboration – disseminate results – share profits equitably – increase research capacity – build on the achievements". In the next section we emphasize the necessity of taking technology into account in cooperation programmes.

INSERT TECHNOLOGY AND INNOVATION AS COMPONENTS IN ECONOMIC AND FINANCIAL AGREEMENTS

Usually, economic cooperation is treated independently of scientific cooperation. For instance, the current debt reduction initiatives provide nothing for science and technology and the financial resources available are devoted mainly to basic and secondary education. The idea of inserting science and technology in the global framework of cooperation is already present in the New Partnership for Africa's Development (NEPAD) documents, the strategy of European Union for Africa and the strategic plan of the African Development Bank. However, it is necessary to treat technology and innovation as components distinct from science, by inserting them within commercial contracts, as it is done for instance in aeronautics with China.

CONCLUSION

Science has arrived in Africa as an imported "finished product". Little effort has been made to valorized local knowledge and practices which, in the colonial period were qualified as barbaric, savage or primitive, as exemplified in the first version of the Cameroonian National Anthem. As a consequence, education to science is perceived by most Africans not as a universal process aimed at helping people to improve their old practices and master their environment, but rather as a bridge which can let them move from their ancestral and valueless practices to the modern European world. This is why even today progress in education is not converted in Africa into real improvement in the area of societal organization and living conditions. In a strategic domain such as energy, very simple measures could be taken to reduce consumption and save money but very little is done. How is it possible then to promote high-level research in this domain?

On the one hand, there is a dichotomy between science and technology. It is recognized that local effort is necessary for the diagnosis of African problems and the development of specific scientific tools for their solution. On the other hand, it is implicitly assumed that the technology implementing the scientific solutions is of a universal nature and can be developed in the North and transferred directly to the south through finished products. This situation must change.

Following Mve Ondo[4], we can conclude that progress in science and technology in Africa requires not only financial and organisational measures, but also a "certain number of radical breaks: a break with traditional ways of thinking; a break with the rejection of science as white man's business; a break too with consumerist mimesis; and lastly a break with the commodification of knowledge". Progress in this social aspect will lead to tremendous improvements as it can be seen in areas such as the fight against malaria and HIV Aids where the simple tools of impregnated mosquito nets and preservatives are very efficient.

Notes

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2. KFPE (Swiss Commission for Research Partnership with Developing Countries), http://www.kfpe.ch
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7. R. Waast, The state of science in Africa, Ministère des Affaires Etrangères, Paris, April 2002

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Abdel Salam Majali FIAS served as Prime Minister of Jordan during 1993–1995 and 1997–1998, and is currently Chairman of the Jordan Senate Foreign Relations Committee. A professor of medicine since 1973, he previously served as ENT Consultant and Director General, Royal Medical Services, Jordan Armed Forces (1960–1969); Minister of Health (1969–1971) and Minister of State for Prime Ministry Affairs (1970–1971 and 1976–1979); President of the University of Jordan (1971–1976 and 1980–1989); and Minister of Education (1976–1979). He also was Chairman of the University Council, United Nations University (1977–1982) and a Member of the Executive Board of UNESCO (1985–1990). Dr. Majali holds an M.D. degree from the Syrian University. He is a Fellow of the Third World Academy of Sciences and President of the International Affairs Society (Jordan).

SCIENCE AND TECHNOLOGY IN A GLOBALIZED WORLD: PRESENTING THE CASE FOR ICT AND HEALTH

It is a privilege to be amid this eminent gathering of academics and science and technology makers, here in Yokohama city, under the auspices of UNESCO and the UNU to delineate a scientific outlook on how we can move forward in the realm of science and technology for the benefit of humanity today, and tomorrow.

The world is witnessing a state of global transition. We are observing the unfolding of one dramatic event after another. The eminent participants gathered here represent a wide array of UN off-shoot agencies that are concerned with the realization of sustainable development through scientific and technological means. We should engage the political decision-making community in our attempt. This inextricable link between the makers of policy and policy makers should be bridged if our efforts are to bear fruit.

I must in this context commend the efforts of the UNU and its various offspring; as well as the UNESCO, the International Council for Science (ICSU); and our own Islamic World Academy of Sciences (IAS), for always attempting to reach out to the political decision-making community in our countries.

Science for sustainable development has become the maxim for scientific organizations, university academics, ministries of science and technology, and science academies. The knowledge that science can generate is a prerequisite for a sustainable future. For this, we need research – research that takes a holistic perspective and brings together different disciplines and research communities.

In a world moving rapidly toward the knowledge-based economies, capacity building in science and technology (S&T) is necessary everywhere. But the need is greatest for the developing nations. We need a global movement to address this need, which has been insufficiently addressed... even neglected altogether.

Whether we describe this phenomenon as a move toward 'knowledge-based societies,' it is clear that future economic and social well-being will derive from the mastery and creative application of knowledge; as well as from the possession and exploitation of tangible materials.

This profound transformation is obviously affecting different parts of the world in very different ways. The industrialized nations have largely dominated contemporary economic activities and processes, enjoying an abundance of scientists, laboratories, and investments in research and development (R&D). Thus, they command an overwhelming share of the patents granted for innovations in an increasingly well-governed international system of intellectual property rights. Are they however sharing the fruits of their efforts?

I must here note with appreciation the effort of the UNU-IAS and UNEP in terms of documenting occurrences of bioprospecting in Antarctica within the context of the Antarctic Treaty Consultative Meetings (ATCMs). The effort of the UNU-IAS in terms of developing a database of patents and applications for patents, companies involved, commercialized products and where possible their market values is to be commended and supported.

Humanity has benefited enormously from advances in science and technology during the last century: people are living longer, healthier, and more productive lives than ever before. Today, we are witnessing greater-than-ever acceleration in the rates of development and dissemination of new knowledge in all fields. Never in history has there been more scientists and technologists engaged in science than today.

There is always room for improvement in the practice of science and technology and for enhancing research capacity in the high-income industrial world. The overarching problem lies however in the low-income developing world. The vast majority of people in most societies are falling further and further behind in their ability to master the new knowledge and benefit from its fruits in their everyday lives.

It is inconceivable that there should be 800 million people going hungry in a world that has sufficient resources to provide for the most basic of all human needs. The condition of hunger today is perhaps as monstrous as slavery was in the 19th century. It was indeed Abraham Lincoln who said that "a house divided cannot stand; a nation half slave and half free." I wonder if we can continue to live in world that is half hungry!!

The helplessness of most of the developing world to keep pace with the rapid changes occurring in the various fields of S&T indicates that current models of technology transfer and international assistance are not working as well as many would have hoped.

It is imperative that all nations, particularly developing ones, attain an increased level of S&T capacity to enhance their ability to adopt new technologies – as in those related to the new life sciences – and adapt them to local needs. There is an urgent need to evaluate current practices and propose a comprehensive overhaul of the approach to capacity building for science and technology.

A closer look at the problems and ills, scientific and otherwise, in the developing world today reveals that they are transreligious, trans-cultural and cut across the barriers of religion, language, colour, gender or creed…

Science leaders should aim to always integrate not segregate, …extend their hand to their neighbours in friendship and not barricade themselves behind the hideous mask of seclusion.

A major trend shaping science today is globalisation. Despite the fact that many people claim that we have now entered into the age of deglobalisation – with the fruits of globalisation drying up. There is growing technology demand from emerging economies. There is increasing world recognition of the interconnectedness of the planet's biophysical systems and improved communications, especially via the Internet. All these forces are boosting cross-border scientific cooperation and information exchange between individual researchers, institutions and governments. However, much of the expansion is occurring outside the boundaries of the countries of the South.

The words of former US President Jimmy Carter described the dilemma of globalisation rather succinctly when he said, "Globalization, as defined by rich people like us, is a very nice thing... you are talking about the Internet, you are talking about cell phones, you are talking about computers. This doesn't affect two-thirds of the people of the world."

The twentieth century witnessed global war, population explosion, space exploration, unimaginative strides in Information Technology, and unthinkable feats in Biotechnology. We in the Third world need to ask ourselves, as to whether our contribution to some of these events was of a magnitude that reflects our historical and cultural size or even our wealth of natural God-given resources.

With only a handful of exceptions, countries of the South are still mostly exporters of raw materials, inexpensive agricultural products and low-technology manufactured goods. Sizeable developing countries still suffer from adult illiteracy, indebtedness, food insecurity as well as environmental degradation. Our contribution to global wealth is significantly small when compared to industrialized countries.

The 1999 World Conference on Science discussed at length the topic of 'science for man.' In its final declaration on science and the use of scientific knowledge, this notion was expressed by that conference:

- science for knowledge
- knowledge for progress, which included science for peace, science for development; and
- science in society and science for society.

We must again highlight the ways in which science can help in developing and promoting the specifically human dimension of man, society, and the environment.

At the same time, we should also discuss the ways in which, in certain situations, use, misuse and abuse of science can be responsible for a decline in the quality of life, as happens in the case of damage done to the environment, the consequences of the invention and use of sophisticated weapons, etc.

The second part of this topic, 'man for science', involved identifying the impact of recent scientific discoveries and advances on our vision of man, both directly and indirectly.

Recent decades have witnessed significant changes in knowledge production systems, especially in scientific research and related applications. And more changes in knowledge production and systems of research and development (R&D) are in motion. The quickening pace of globalization fuels these changes.

Indeed, Globalization itself was fuelled by new developments in information and communication technologies (ICTs), in biotechnology, and in the field of materials science and engineering including Nanotechnology. These are primary manifestations of transformational technologies. I think at some point we have to add Cultural Technology as manifested by the explosion is satellite television...

Developing countries must move toward a process of technology-supported progress, where different sectors can continually develop in response to knowledge production. They cannot simply watch wave after wave of transformational technologies pass without due regard!

We must ride these Information Technology, Biotechnology and Nanotechnology waves with confidence and determination. We must 'plug into' the transformational powers of these technologies, and not stand idly by, and see us left behind.

Of the Transformational Technologies, Information and Communication Technologies (ICT) has already had an enormous impact on healthcare in developing countries. It has enabled healthcare workers to conduct remote consultation and diagnosis, access medical information, and coordinate research activities more effectively in the past two decades than in the history of medicine.

In poor countries such as Gambia, for example, nurses in remote villages use digital cameras to download images of symptoms and transfer them to nearby towns for examination by doctors. The same model is being applied to facilitate collaboration among physicians themselves. When an expert opinion is required, doctors in rural towns send the images captured by the nurses to specialists in the UK for advice. Hospitals in my country Jordan often hook-up to Mayo Clinic in the US for joint seminars and for sharing information.

The principle of ICT-facilitated collaboration extends to medical research also. This is illustrated in West Africa, where malaria researchers use a network of satellites and ground stations to submit data for clinical trials conducted at tropical disease research facilities in London and Geneva.

Health workers in developing countries are accessing relevant medical training through ICT-enabled delivery mechanisms. Several new malaria Internet sites for health professionals include innovative 'teach and test' self-assessment modules. In addition, centralized data repositories connected to networks enable remote healthcare professionals to keep abreast of the rapidly evolving stock of medical knowledge. In Bangladesh, for example, the local

MEDINET system provides access to hundreds of medical journals via email for less than US$1.50 per month.

We at the Islamic World Academy of Sciences (IAS) have too joined the open access bandwagon and opted to have our medical journal readily available on the Internet free of charge.

When applied to disease prevention and epidemic response efforts, ICT can provide considerable benefits and capabilities. Radio and television have a long history of effectively facilitating the dissemination of public health messages and disease prevention techniques in developing countries. In Jordan, we have recently embarked on a television-based anti-smoking campaign that is engendering quite an impact.

The Internet can also be utilized to improve disease prevention by enabling more effective monitoring and response mechanisms. The Internet is used for example, across Sub-Saharan Africa, to monitor daily cases of meningitis and to help coordinate mass vaccination programs when threshold levels are reached.

A number of countries, such as Estonia and Costa Rica, have invested in ICT to improve the administrative efficiency of their public health systems and ICT can also be applied to improving the efficiency of medical facility administration through, for example, the streamlining of medical procurement or the creation of patient record databases.

The role of ICT in achieving health-related internationally recognised yardsticks such as the Millennium Development Goals is indispensable. ICT is an invaluable tool for both healthcare workers and the international development community in reducing child mortality, improving maternal health, and combating HIV/AIDS, malaria, and other diseases.

Childhood diseases prevented 9 percent of the world's children from living to see their third birthday. Healthcare workers can use ICT to establish databases to track vaccination programs, coordinate shipments of antibiotics, and inform communities of medical services that can prevent child mortality.

Maternal death is the leading cause of death for women of reproductive age in the developing world. ICT can critically reduce the incidence of maternal death numbers by facilitating access to information and healthcare services.

In the fight against HIV/AIDS, ICT can strengthen disease monitoring and management, drug distribution systems, disease monitoring and management, drug distribution, training of caregivers, patient education and monitoring, and support networks for people living with HIV/AIDS and the people who care for them.

The potential to enhance the response to HIV /AIDS has not yet been fully leveraged in the countries most affected by the crisis. Many of these countries lack the infrastructure and the human capacity required to implement comprehensive strategies that could improve prevention, treatment, and policy support.

Several initiatives to use ICT to prevent and treat HIV/AIDS are currently under way. These initiatives range from networks aimed at enhancing access to knowledge on HIV/AIDS treatments to the use of geographic information systems to map the spread of the disease in relation to socioeconomic variables and treatment.

In some cases, clinical information infrastructure systems and simple mechanisms have been used to address the logistics of distribution and monitor the use of essential drugs. Virtual forums and lists have facilitated the discussion of access and treatment, enhanced advocacy, and raised awareness.

For the potential benefits of Information and Communications technologies to be realized in developing countries, many prerequisites need to be put in place: prompt deregulation, effective competition among service providers, free movement and adoption of technologies, targeted and competitive subsidies to reduce the access gap, and institutional arrangements to increase the use of ICTs in the provision of public goods.

Given the diverse potential benefits of Information and Communications Technologies, especially in the provision of public goods, subsidies traditionally used for poverty alleviation could be adapted to create incentives for the use of ICTs. For example, conditional cash transfer programs, which are largely tied to education or health, could be implemented at the community level to provide Internet access to children where educational and health services are delivered.

I must in this context place a note of appreciation to international organizations that were born globalized; the UNESCO and the WHO, and the tremendous commitment and untiring effort to fulfil their very extensive mandates. As someone who has been involved in the executive end of things in both organizations I witnessed this first hand.

Information and Communication Technologies offer an opportunity for development, but not a universal remedy. We need to re-evaluate our appreciation of science. The physicist and Biologist Jacob Bronowski described science as the "organisation of our knowledge in such a way that it commands more of the hidden potential in nature." He claims that the values of science are not rules. They are, in Bronowski's words, "those deeper illuminations in whose light justice and injustice, good and evil, means and ends are seen in fearful sharpness of outline." That was in 1956, long before we were thinking of what the new millennium would bring us.

The new millennium is hardly new at all. There is nothing new in the anger and violence springing up everywhere. There is nothing new in unjustified or even justified actions that involve the use of force. Indeed, if we continue to depend on the rule of force, on power, as a deterrent, we will eventually be unable to disable violence. We – all of us in the East and the West - must become more sensitive to the concept of consequences. The consequences of injustice, poverty, illiteracy, lack of opportunity and despair, which can all lead to the contemplation of violence.

As a citizen of the world, and as a medical doctor, I learnt to look for causes, to diagnose, to ask why certain things happen. I realize that intolerance, prejudice and bigotry can also be seen as forms of illiteracy and ignorance, eroding social values, eating away at our humanity and stamping on our sense of ethical obligations and duties - to one another and to the world as a whole.

In our part of the world, we have just seen man-induced death and destruction at its level worst. Within hours of an average border incident that has taken place between two countries; massive military force was unleashed virtually destroying a whole – neighbouring country – within a few days.

How can such a calamity even be considered within the realm of reason or logic? When we take of science policy, we need to talk of politics of science. We need, as developing countries, to be given a breath to be able to better utilise science for development.

It is essential to fully mobilise the international scientific community. The voice of scientists must be heard in political decision-making circles. The science community in the North is morally and humanely obliged to extend a hand to their counterparts in the South.

We need wisdom. We must as scientists demonstrate to the tax-paying public that science pays. The words of Isaac Asimov spring to mind here when he said that the, "The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom."

The science community in the South cannot afford to become detached from society. We must engage our political leaders as well as educate our decision-makers. We have to be committed to showing that science catalyses progress and gives the poor hope for a better future.

We have to take action for time waits for no one. If the new realities have one thing in common, it is the increasing speed of change. Perhaps we as science policy makers from Developing countries take to heart the story of the teacher in Africa, who- in response to those who made fun of the fact that he was always in a hurry – said: "Yes! The clocks are ticketing, my friends. History has a terrible timetable. If we are not careful, we might be remembered as the (generation) where everybody arrived too late!"

Professor Turner T. ISOUN

Honourable Minister of Science and Technology
Federal Republic of Nigeria

Professor Turner T. Isoun is the Honourable Minister of the Federal Ministry of Science and Technology in Nigeria. Previously he was Director and Chairman of the Board of Trustees, and founding father of the Niger Delta Wetlands Centre (NDWC). He was Executive Editor of the African Academy of Sciences. He has served as Vice Chancellor for Rivers State University of Science and Technology and has been a Special Advisor on Science and Technology to the Government of the Rivers State, a lecturer at the University of Nigeria, and a lecturer and Professor of Veterinary Pathology at the University of Ibadan. He has been awarded research and travel grants from the Rockefeller Foundation, the Carnegie Foundation, the German Academic Exchange Foundation (DAAD), the Commonwealth Fellowship Foundation, and the International Development Research Foundation (IDRC). Professor Isoun holds a BSc (Hons), D.V.M., and PhD in Veterinary Medicine and Pathology.

STRATEGIES FOR DEVELOPING COUNTRIES

First, I bring you warm felicitations from the President, Government and people of Nigeria and thank you for the wonderful and warm hospitality. I am very delighted and honoured by your invitation not only to attend this Conference, but also to make my very modest contribution and share views and ideas with the eminent experts and seasoned professionals from all over the world on the vital issues and relationships of Globalization, Science and Technology, Peace, Sustainable Economic Growth and Development.

I am also very delighted to note the growing partnership and collaboration between Nigeria and UNESCO, which this invitation and our participation has further highlighted. There is a special plan of cooperation between Nigeria and UNESCO with elements in Education, Culture, and Science and Technology initiated by Chief Olusegun Obasanjo, President of the Federal Republic of Nigeria on his assumption of Office in 1999. The special cooperation clearly shows our desire and commitment to partner with UNESCO. The Element on Science and Technology is a reform and revitalization project which the Japanese Government, our host today, is playing a key and vital role.

This Conference with the theme "Globalization: Challenges and Opportunities for Science and Technology" is very apt as it aims to discuss the ways in which globalization changes science and technology and vice versa and the opportunities these changes offer in the better utilization of Science and Technology to foster peace, improve the quality of life of our peoples and promote the sustainable growth and development of nations.

The world and its economy has become highly globalized. The major drivers of this phenomenon are our better understanding and utilization of Science and Technology. In fact, it has been rightly and consistently argued over time that the strength or weakness of any nation or people is directly related to their technological capabilities and knowledge. Science and Technology has assisted in virtually all spheres of human endeavour, ensuring higher agricultural productivity, better communication, better healthcare delivery, improved quality of life, among others. It is clear that to make any meaningful progress and sustain development and be able to compete favourably in the technology-driven, knowledge-based, competitive global economy; nations must pay particular attention to issues of science, engineering, technology and innovation. These tools when wisely deployed also foster peace, cooperation and integration. The evidence of improved quality of life, better national socio-economic growth and development driven by technology become obvious when one compare countries with higher and lower technological capabilities.

However, in spite of all the positive attributes of science and technology, its development and use has also posed threats and challenges for the world and its people, especially when not properly channelled. These challenges vary from environmental degradation, sustainable development, to peace and security. There is therefore the urgent and persistent need to encourage and insist on the sustainable use of science and technology to foster peace, improve the quality of life of our people and sustainable economic growth and development as well as cooperation of our peoples and nations.

Nigeria, (like other progressive other nations) believes in the power of science and technology as the engine for national economic growth and development and has initiated a number of activities and programs and has recorded some modest achievements. We do not wish to attempt to re-invent the wheel, but have decided to concentrate our research efforts on areas of comparative advantage such as our bio-resources to assist in feeding and looking after the health of our teeming populations. We have also decided to plug into high and cross cutting technologies to improve the quality of life of our people.

Nigeria is undergoing major strategic and pragmatic reforms in its public policy thrust and taking strategic actions in line with our National Economic Empowerment Development Strategy (NEEDS) document aimed at streamlining the country for optimal performance. These include strategic political, economic, social and financial reforms.

Allow me to highlight a few of our modest achievements in Science and Technology aimed at improving the quality of lives of our people and increase our ability to participate and compete in the global economy.

Government has initiated policies and established relevant implementing Agencies for our flagship science and technology programs in ICT, Biotechnology, Small- and Medium- Scale Enterprises, Energy, and Space Technology aimed at leapfrogging Nigeria's entry into global knowledge economy. There are also other policy initiatives that promote incremental injection of Science and Technology into traditional development processes including the promotion of engineering materials research and development, medicinal plants research and development, and Intellectual Property Rights, among others.

This year 2006, July 6th to be precise, we commissioned a modern Gamma Irradiation Plant in partnership with a German company. This plant is useful in the preservation of fruits, grains and tubers, reduce our post-harvest food losses, hence improve food security, in addition to its being used for primary healthcare. It would also improve the quality of cable and wire products, plastics, natural rubber through radiation-induced linking of their mechanical, electrical and thermal properties.

Also a plant-derived drug (NICOSAN) for the management of sickle cell disease was also launched in July this year. The drug a product of indigenous knowledge research is being produced in joint partnership between the Nigerian Government and an American company. This is crucial to us as about 6million of the estimated over 10million people in the world with the sickle cell disease live in Nigeria.

Similarly a Computer for All Nigerians Initiative (CANI) has been launched. This is aimed at ensuring easy and affordable acquisition of computers by the citizenry. This no doubt would improve the computer skills of the people, enhance internet connectivity and usage and create an enabling environment for research and development, economic growth, employment creation, wealth generation and capacity building for the Nigerian workforce in both the public and private domains.

We are also developing the process for an effective and sustainable funding arrangement for a coordinated, development-oriented scientific R&D activities through the establishment of a National Science Foundation of USD5Billion Endowment. I must add here that UNESCO through the Nigeria/UNESCO Project on Science, Technology and Innovation reform project facilitated, along with others the establishment of this foundation. Details of the mechanisms for one effective and sustainable management of this fund and its legal backing are being worked out.

Nigeria, on September 27th 2003, launched NigeriaSat 1, the first low-earth orbiting remote sensing satellite by a sub-Saharan African nation, with numerous multi-sectoral applications. NigeriaSat 1 contributed useful data for managing the recent Tsunami Disaster, and more recently Hurricanes Katrina and Rita as part of the international Disaster Monitoring Constellation with the United Kingdom, Algeria, and Turkey Low Orbit Satellites. Nigeria has also been admitted to the International Committee on Earth Observation Satellites. NigeriaSat 2 another remote sensing satellite with higher ground resolution (2.5m) is scheduled for launch in 2008 to replace Nigeriasat 1. This project is in partnership with Surrey Satellite Technology Ltd (SSTL) of the U.K. The Nigeria Communication Satellite (NIGCOMSAT-1) is scheduled for launch in the first quarter of 2007. This is being designed, built and will be launched in partnership with China Great Wall Industry Corporation. The Nigerian Space project is an important initiative for the integration of Africa and should be seen as an African project as it is designed to serve the whole of Africa. It is important to note here that we are putting in place a 20 year Space Technology development program with the full political support of the Federal Government of Nigeria. On the Communication Satellite scheduled for launch next year, we have specifically written to all African Heads of State to subscribe to the available bandwidth and over 25 Heads of State have responded positively. This, no doubt, would assist improve communication and all its applications in various other sectors including education and commerce in many African countries.

Energy is not only crucial, but also critical for the development and transformation of Nigeria, and indeed, Africa. Nigeria requires adequate and diverse energy sources to assist it develop all its capacities, including Small and Medium Scale Enterprises that would impact positively and significantly on the lives of our people. On energy, in our quest to diversify our energy resource base, we have a research nuclear reactor. Though a very small step, yet significant for us, because this reactor and the Gamma irradiation facility can be effectively utilized to conduct research and training activities with multi-sectoral applications. We have also, this year, activated the Nigeria Atomic Energy Commission with the primary responsibility to promote and streamline the implementation of a proactive nuclear technology development program for peaceful applications in electricity generation, agriculture and food security, medicine, industry and in basic and applied scientific research.

In Telecommunications, we have been able to grow telephone from under 400,000 lines in 1999 to over 25 million today since the inception of the President Olusegun Obasanjo administration and still growing rapidly. This remains one of the fastest growing sectors. We are also developing telecommunication backbones both terrestrial and satellite based, christened the national Information and Communication Technology Backbone covering the entire country. This project is being developed in phases.

There are also a number of other achievements in ICT, Biotechnology, especially in diagnostic test kit manufacturing, and in traditional medicine development which include the documentation and digitalization of our traditional knowledge and developing a digital virtual library for traditional medicine, perhaps the first such focal reference centre in Africa, aimed at developing and improving the use of our bio-resources and biodiversity. We are also working to address issues of Patents and development of appropriate regimes for Intellectual Property Rights protection including those for our vast Traditional Knowledge base.

Nigeria has also initiated, with the assistance of UNESCO, a project for the Reform and Revitalization of Nigeria's Science, Technology and Innovation System aimed not only at streaming and optimizing Science and Technology for Nigeria's global competitiveness, enterprise development, wealth and job creation, but also at reinforcing our science, technology and innovation infrastructure and enhancing its utilization for the attainment of macro-economic and social objectives.

The Project has a regional component that would assist other African countries develop proposals to reform, revitalize and build managerial capacities of their Science, Technology and Innovation systems. This Project is being co-financed by the Government of Japan through its Funds-In-Trust for Human Capacity Building with UNESCO. The Science and Technology Innovation institutional reform landscape covers 156 R&D institutions, over 70 Universities, over 50 Polytechnics, numerous colleges of Education and Agriculture, some private R&D Establishments.

Noting the critical need to promote creativity, inventions and innovation as factors for national development, economic growth and global competitiveness as well as a basis for better humanity, the Nigerian Government has set up a Presidential Standing Committee on Inventions and Innovations, aimed at encouraging innovations in Science and Technology, by receiving, assessing and validating inventions and innovations and ensure the commercialization of promising and feasible inventions and innovations.

Aware of the important and vast potentials, roles and contributions of our citizens in Diaspora in national economic growth and development especially through science and technology, we are engaging, interacting and partnering with our citizens in Diaspora. We are aware of the critical role citizens in Diaspora have played in countries such as Japan, (our host today), Taiwan, South Korea, China, India among others and wish to tap into this vast potential. We are encouraged by the enthusiasm and willingness of our citizens in Diaspora to contribute to our efforts at nation building. We are therefore hopeful that our present engagement, interaction with them would not only assist in nation building, but also foster peace, national integration and cooperation. It is estimated that about 17million Nigerians are in the Diaspora (including those residing in other African countries). Of these about 4million are said to be professionals with various levels of training and experience. We plan to turn brain drain into brain gain.

We are supporting the revitalization of our Science and Engineering Academies as they have vital roles to play in the development of our National Science and Technology enterprise. Nigeria also contributed USD5Million endowment to the African Academy of Science. This is because of our belief in the power of Science and Technology serving as the engine for national economic growth and development for African Countries.

The Academies are very useful in the quest for the development of Science and Technology to improve the quality of life of our people, create jobs and wealth and empower our nation to become more competitive in the emerging knowledge-based, science and technology-driven, globally competitive economy. Our national Academies are being revamped to enable them play more critical roles in national development. They therefore need greater financial and material support.

We are working to develop world-class scientists, scholars and Centres of Excellence in the cutting edge technologies in our national priority. We are also designing strategies to include and engage the private sector in our activities, especially in funding value-adding R&D, commercialization activities including the now being revamped technology incubation schemes. A National Nanotechnology Initiative has also commenced in a focused, prioritized manner.

It is an obvious fact that science, technology and innovation systems serve as the engine for modern enterprise and national development. We are therefore working to encourage and inspire our youth to become world-class scientists and scholars and contribute in the use of science and technology for our economic growth and development.

A Presidential Retreat on Science and technology encompassing Science and Technology and innovation stakeholders was held on August 10, 2006. It was a most fulfilling exercise as there was an overwhelming response from stakeholders from government, academic, industry, international and diplomatic community with their multiple sub-sectors all represented, including Nigerians from the Diaspora. These reforms oriented Retreat will further drive the accelerated development of a science, technology and innovation driven knowledge economy.

I would like to thank all of you, especially the United Nations University and UNESCO, the Government and People of Japan and our other partners and formally invite you to come, see, feel, partner and invest in Nigeria and join us in our quest, commitment and determination in moving Nigeria to a higher level of global socio-economic inclusion and relevance through the deployment of the tools of Science and Technology.

Hans d'ORVILLE

Director, Bureau of Strategic Planning, UNESCO

Prior to joining UNESCO in 2000, Hans d'Orville served as Director of Information Technologies for the Development Programme, Bureau for Development Policy, United Nations Development Programme (UNDP). Since 1975, he has held a variety of posts in the United Nations Secretariat and at UNDP. From 1987 to 1995, he served as Executive Coordinator of the InterAction Council of Former Heads of State and Government. Dr. d'Orville is a member of the Executive Committee, Africa Leadership Forum, and was advisor to the Independent Commission of Population and Quality of Life and the Independent Commission on Forests and Sustainable Development. He holds a Ph.D. in Economics from the University of Konstanz (Germany).

KNOWLEDGE SOCIETIES AND SCIENCE, TECHNOLOGY AND ENGINEERING: PUBLIC-PRIVATE PARTNERSHIPS AS NEW PARADIGMS TO PROMOTE INTERNATIONAL COOPERATION

THE CASE OF THE MONDIALOGO PARTNERSHIP AND ITS ENGINEERING AWARD AND THE L'OREAL-UNESCO PARTNERSHIP FOR WOMEN IN SCIENCE

SCIENCE AND TECHNOLOGY IN THE GLOBALISATION EQUATION

The **processes of globalization** affect all societal spheres, impact on national developments and influence the direction and operations of all sectors, including science, technology and engineering. These processes entail increased global flows and movement of information and communication, capital, goods and people worldwide. **Globalization** brings about a **greater interdependence between countries from all regions.** The environment is one sphere where due to globalisation problems by their sheer scale and gravity may impinge on human well-being and safety and may even generate new forms of conflict. This may be partly due to the competition for scarce, if not dwindling, progressively degrading and increasingly expensive natural resources. Conflicts may occur over or involve land, water, mineral and energy resources, aggravated by the impact of climate change (rising sea level, intense storms and hurricanes, continent-wide « dust bowl » effects, reduced food security). Poor countries in particular will find it exceedingly difficult to cope with the consequences of climate change. Global warming will increasingly have an impact on access to water, food security, flooding of large areas, and the health situation (e.g. the annual number of malaria cases is expected to rise from 50 million a year to 80 million by 2100). The use, availability and quality of water and related ecosystems will be of paramount importance. Currently, an estimated one billion people has no access to clean drinking water and 2.6 billion are without adequate sanitation. Challenges to devise scientific and technological solutions are only part of the equation – the other part comprises the need to apply sustainable water management, good governance and to protect cultural and biological diversity.

Science and technology, especially from the perspective of **sustainable development and sustainability**, **will play an increasingly central role to safeguard and enhance human security,** ranging from imparting and sharing knowledge about scientific and environmental processes to action through the scientific programmes and scientific networking. **The objective is to empower countries to build their knowledge base**. **Water and the oceans** have moved to the top of the international agenda. The improvement of **Earth Observation** is a prerequisite for the planning of sustainable, environmentally sound socio-economic development. The effective **management of risks related to global hazards and natural disasters** will become a global priority, as will be the necessity to set up scientifically-based early warning systems., as the lessons from the tsunami tragedy and other natural disasters have.

Technoscience needs to – and is likely to - make further strident advances. For the first time in history humankind will be capable to genetically modify itself, highlighting the ethical, legal and normative limits and barriers of the scientific knowledge upon us. While advances in science and technology, especially in the biological field, offer new hope for the development and well-being of societies and individuals, such as in agriculture, they raise at the same time novel and grave ethical questions. Managing globalisation is impossible without an **ethical underpinning based on shared values**.

Globalization is accompanied by the emergence and re-emergence of infectious diseases. The rapid increases in the number of people travelling over long distances and in the movement of goods across boundaries and oceans, introduce new, as yet unmanageable **new global security issues**, as has been seen by the spread of diseases and epidemics – such as SARS or bird flu – which may cause new, rapidly multiplying global **health crises** in the form of epidemics. **HIV/AIDS,** with its inter-generational and borderless nature, poses an exceptional challenge to development, progress and stability of societies worldwide and will require much more attention and action than in the past. Increasingly, the face of HIV/AIDS is a woman's face, with women having greater vulnerability to infection due to social, cultural and physiological reasons. There is a high expectation to scientific advances in order to keep in check HIV/AIDS, limit the spiralling costs of HIV treatment and scale up prevention efforts must be scaled up. Similar and additional measures must be taken to fight other infectious diseases, such as malaria or tuberculosis, through a strengthening of health systems and innovative delivery approaches.

The **information and communication revolution**, comparable in its impact with the industrial revolution, is bringing about a substantial restructuring of societal arrangements, interaction and networking. It offers enormous new opportunities for social and human development, for poverty alleviation and for science and technology, not least facilitating the worldwide exchange of knowledge for the benefit of many. the spread of new information and communication technologies, has undeniably brought about greater connectivity within the global community, as well as broader and in some respects more equitable, but in other respects more restricted access to information and knowledge. While certain parts of the population have grown closer together, others have been further sidelined or left behind, with globalization causing new and ever deeper forms of exclusion and disparity… A content divide is also developing, as more and more information, including scientific knowledge, will be digitized and protected by DRM (digital rights management) structures. The possibilities for harnessing knowledge and promoting its sharing through ICT-enhanced media will continue to increase in line with the rapid evolution of ICTs.

The demands, expectations and challenges are enormous. To be sure, the evolving processes of globalization have spawned advances in research and technology, financial innovations, managerial and operational improvements, social developments and even the evolution of educational methods and tools: all have become increasingly universalized, transcending social, cultural and national boundaries. A knowledge- and innovation-based development holds unique possibilities for bridging disparities, and for making globalization work for all – but only if it is deployed in an equitable, inclusive and culturally-sensitive manner.

What does it mean to build and nurture **knowledge societies**? Information and knowledge is often a defining feature of modern societies. Access to information in all spheres of human activity – and the ability to use such information effectively – has become increasingly crucial to economic growth, poverty alleviation and sustainable development. Today, knowledge is thus not only a critical determinant of individual professional success. Rather, knowledge through transmission, reproduction and innovation is bound to have profound implications for all aspects of societal activity and evolution. Indisputably, all types of knowledge represent nowadays a distinct public good. Access to knowledge is considered a matter of social justice and equity, as all too often, knowledge is reserved for small and privileged groups of nations or segments of societies. Knowledge societies will only be able to usher in a new era of sustainable development if they ensure universal access, provide quality education for all, allow broad-based participation and thus empower people – regardless of race, sex, language, religion, income or class, or where we happen to live.

What kind of knowledge are we referring to? UNESCO's commitment to protecting and promoting cultural diversity, as captured in the 2003 UNESCO Universal Declaration on Cultural Diversity, directs our attention away from technological and scientific knowledge towards its more social and cultural aspects and to local and indigenous forms of knowledge. Only a holistic, integrated and balanced concept of knowledge, which preserves and promotes genuine pluralism, will be able to ensure the development of an inclusive culture of innovation. Through dialogue, exchange and education, UNESCO actively pursues such a holistic approach, seeking to bridge different forms of knowledge – traditional and new, cultural and scientific, local and global – and mobilize the unique potential of each.

The necessity of promoting intercultural exchange represents one of the central challenges of our time. In today's globalising world, it is crucial to build up cultural competence - especially for the young generation – as youth bears the responsibility for the world of tomorrow. Both the natural and the social and human sciences can make a significant contribution to that effect.

The transmission of knowledge does not happen in a vacuum; it is mediated through the vehicle of language. The preservation and promotion of linguistic diversity is therefore of utmost importance. It is estimated that there are over 6,000 languages spoken in the world today, with 96 per cent of these spoken by just 4 per cent of the world's population. At least half of these languages are in immediate danger of disappearing. Respecting and promoting linguistic diversity in all areas of the knowledge system – education, research and development – is a prerequisite for the preservation of the diversity of traditional knowledge systems and cultures.

Science and technology, as major components of the world's knowledge and as one of the drivers and beneficiaries of globalization, acquire a special role for enhancing cooperation, collaboration, dialogue and exchange among people from different cultures, traditions and religions. Historically, science as a common heritage of humanity has always been a vector of dialogue and understanding among scientists of different cultural, religious backgrounds. Accordingly, UNESCO has always encouraged the creation of scientific associations, organizations and networks that group scientists from various regions around common objectives and as a mechanism to collaborate and exchange experience for the larger good. In that connexion, UNESCO was also instrumental in the establishment of the World Association of Young Scientists (WAYS) whose membership covers scientists from more than 120 countries, linked by the desire to work together and get their voice heard in the area of science policy making. Another example is the Israeli Palestinian Science Organization (IPSO). Established with the help of UNESCO, IPSO promotes cooperation among mixed teams composed of Israeli and Palestinian scientists and provides funding for joint projects. UNESCO also promoted the organization of international exhibitions, conferences and symposia to promote scientific advances and innovations and to share scientific and engineering knowledge. If all civilizations contribute to these advances, all civilizations shall be enabled and privileged to learn about and benefit from them.

Likewise, to succeed in these efforts, a broad range of partners and stakeholders will need to be mobilized, including NGOs.

THE MONDIALOGO PARTNERSHIP BETWEEN UNESCO AND DAIMLERCHRYSLER

The Mondialogo Partnership is a prime example how science and technology can help to glue young people together in the era of globalisation, taking advantage of the power, outreach and transformative potential of ICTs. DaimlerChrysler and UNESCO joined hands in 2003 to create a partnership with the mission to promote a paradigm of intercultural dialogue, exchange and understanding among young people around the world

UNESCO is enjoined by its 1945 Constitution to promote peace and international security through international cooperation in education, science, culture and communication and information, ultimately aimed at "building the defenses for peace in the minds of men". Accordinlgy, UNESCO accords high priority to encouraging and facilitating a dialogue among civilizations, cultures and people drawing on all these domains.

DaimlerChrysler – one of the signatories of the UN Global Compact – as a globally active institution devoted to continuous research, scientific and engineering development, training and education, possesses the expertise and resources to contribute to intercultural dialogue – not least due to the fact that it has thousands of employees in numerous countries and cultures all over the world.

Both partners felt that their joint involvement and partnership could provide a boost for international recognition and public impact to the objective of inducing young people with different origin, language, upbringing and culture to learn about and how to approach each other in an open manner. With Mondialogo, school students and young engineers are offered the chance to exchange views and share experience with people of the same age group throughout the world, to broaden their knowledge of other cultures, peoples and religions, to experience practical collaboration around joint projects and positive action in a creative fashion, to form networks and to make new friends in a global setting. In sum: the partnership seeks to promote genuine dialogue and understanding between cultures, while upholding cultural diversity.

Launched in 2003, Mondialogo comprises three distinct action-oriented pillars: the Mondialogo School Contest, the Mondialogo Engineering Award and a dedicated interactive Internet Portal (**www.mondialogo.org**) to serve as a platform in support of the various project activities. Initially designed to run for a period of three years, the partnership has since been extended until 2009 with full funding.

The *Mondialogo* School Contest is the largest international school contest in the world. It aims at promoting and instilling to values and habits of dialogue from an early age on as part of quality education through concrete experiences based on the principle of learning to live together. The Contest encourages teams of students – between 14 and 18 years of age - worldwide to enter into dialogue in order to practice understanding, tolerance and respect through practical projects with strong components of cross-cultural communication. The focus of the Mondialogo School Contest is on children/adolescents. They are open to new perspectives, can be challenged and their curiosity can be stimulated. Teachers are critical for implementing the project as part of classwork. In order to increase participants' motivation - and readiness to do the extra related work. Additional incentives are created for teachers/schools, for example by providing participating teams materials necessary to support instruction, PC cameras or a subscription to the National Geographic magazine. Participating school teams are being paired on a random basis with a partner school team from a different continent and country. It is then the task of the two paired teams to initiate and conduct a dialogue with each other by Internet, telephone, fax or post and to join together in planning and implementing a project. Whether it would be the performance of a play, the creating of a web page, the composition of music and songs and their recording on CDs, tape or video, the compilation of a photographic documentary or collage, the joint writing of stories, poems, fairy tales or plays, design an article of clothing or jewelry, or the production of culturally relevant books, the teams are called upon to pool their creative energies and produce a joint project as their mandatory entry for the competition.

The positive outcomes of the very first round of the Contest (2003-2004), which attracted some 1,500 school teams involving some 25,000 secondary school students from 126 countries – well about twice as many as the organisers had hoped for in their wildest dreams -, are actually being further outpaced by the responses received in the second round 2005/2006. For this second round, which is under way since late last year, the Mondialogo School Contest counts 35,000 participants from 138 countries. An educational symposium and award ceremony for the 50 finalist teams will take place in Rome from 4 to 7 November 2006. An international jury will meet at UNESCO HQ in Paris in September 2006 to evaluate the results of this round and to pre-select 50 teams for the final round, which will be held in November 2006 at a symposium in Rome, Italy, at which the winning entries will be presented. The finalists will be selected on the basis of the quality of documentation of the project, the demonstrated teamwork and engagement, the relevance to the subject of intercultural dialogue, the artistic merit and creativity, and the degree and quality of dialogue among partner teams from different cultures.

The *Mondialogo* Engineering Award (MEA) is a competitive worldwide grants programme, designed as a technological challenge project with a strong emphasis on engineering, technical and vocational education and the identification of sustainable solutions to development. Access to, and use of, latest technological achievements and knowledge are extremely limited, particularly in least developed countries. In poverty eradication, many areas of basic needs relate to knowledge and technology transfer and application in water supply, health care, energy, transportation and job creation.

MEA seeks to induce student engineers and aspiring young engineers at educational institutions to form multicultural teams, integrating participants from developing and developed countries alike, to design engineering projects and prepare proposals that can contribute to the attainment of the United Nations Millennium Development Goals (MDGs), especially by improving the quality of life and contributing to poverty eradication and the promotion of sustainable development. The emphasis is on demonstrating the value of multicultural dialogue through engineering projects furthering major international development goals, fostering also knowledge transfer, capacity-building, and the development of human and institutional resources. The MEA Grants Programme is orientated at three levels: (i) promoting the exchange of information and know-how, including local knowledge and support through international networking; mediating of partnerships between educational institutions and corporations in developing and industrial countries; worldwide presentation and promotion of prize awards; (ii) strengthening of local human resources; and (iii) Provision of materials and equipment as well as training. The target audience is more than 6000 educational institutions (schools and universities) in developing countries and industrial countries, junior staff and experts in the areas of engineering and technology, national and international NGOs such as the World Federation of Engineering Organisations (WFEO), professional organisations in the areas of engineering and technology, ministries and government offices in the areas of engineering and technology.

In its first round (2004-2005), the Mondialogo Engineering Award brought together 111 project teams representing some 1,700 young engineers from 79 developing and industrialized countries. As a result of their collaborative work, they submitted proposals for engineering solutions tackling poverty and promoting sustainable development in all regions of the world. Twenty-one project teams were chosen for the award by a distinguished international jury, based on the criteria of technical merit and excellence, innovation, sustainability, feasibility and intercultural dialogue within a project group. The awards were presented in May 2005 in Berlin. Proposals were focusing on solutions for sanitation and water management, waste management, food production and processing, transportation systems, housing and shelter, communication, use of renewable energies, medicine and health care, development of natural resources, emergency and disaster response and reconstruction, and industry and manufacturing. The Award has already helped to build sustainable networks for dialogue and knowledge-sharing across national, economic and cultural divides. For the second round of the Mondialogo Engineering Award (2006-2007), students from around the world are again invited to work together on project ideas along the same lines. The deadline for registration is 30 November 2006. In order to take part in competition, students should register online at: **www.mondialogo.org** . The next awards will be presented in 2007: 10 teams will each receive cash grant awards of € 20,000. 20 teams will each receive € 5,000.

The third pillar of the partnership, the *Mondialogo* Internet Portal (**www.mondialogo.org**) represents an online platform to foster and facilitate dialogue. It supports directly the implementation of the two main partnership pillars. Its content features general partnership information, provides editorial coverage, promotes active dialogue between people of different cultures (including visitors to the site) and serves as a forum for sign-up, communication, interaction, project development and refinement as well as shared work among project teams and networking. The portal also allows educational institutions, students, and teachers to register on-line and to obtain information about the task, deadlines, and terms of participation for the projects. Furthermore, it offers a closed forum for involved teachers as well as for students to exchange experiences and accompanying events such as expert chat sessions. The portal also presents on a quarterly basis an online Mondialogo journal. Overall, it has supported a degree of on-line interaction and creativity that could not have been anticipated and the quality of the website has drawn wide praise.

The Mondialogo Partnership benefits from the involvement of international personalities who have agreed to serve as Mondialogo Jury Members and Goodwill Ambassadors – to advise, to help publicize the initiative and its visibility, to engage with participants and thus make their involvement more meaningful and exciting. For the School Contest, the Jury members included the authors Paulo Coelho from Brazil; Henning Mankell from Sweden; the astronaut Sheikh Modibo Diarra of Mali; the artist Countess Setsuko Klossowska de Rola from Japan; former Icelandic President Vigdis Finnbogadottir and the musician Marcel Khalife of Lebanon.

The international jury for MEA included Prof. Peggy Oti-Boateng (Director of the Technology Consultancy Centre at Kwame Nkrumah University, Ghana), Prof. Shirley Malcom, USA, (Head of Education and Human Resources for the American Association for the Advancement of Science), Prof. Dato Lee-Yee Cheong from Malaysia (President of the World Federation of Engineering Organizations, WFEO), Prof. Wei Yu (Director of the Research Center for Learning Sciences, Southeast University, China) and Prof. Gülsün Saglamer (Istanbul Technical University, Turkey). Chairmen of the Jury are Deputy Director-General of UNESCO Prof. Marcio Barbosa (Brazil) and Chief Environmental Officer of DaimlerChrysler AG Dr. Herbert Kohler (Germany).

Over the past three years, this strategic public-private partnership between UNESCO and DaimlerChrysler has been highly successful in involving young people and also in attracting the attention of policymakers and leaders worldwide. Indeed, *Mondialogo* has become a distinct brand for building successful long-term intercultural understanding through practical action. It has garnered several international prizes and awards to honor its innovative approach and overall contribution: Germany's prestigious "Freedom and Responsibility" Prize, the Best Global

Website Award and the UK-based IVCA Clarion Award for "outstanding contribution to the debate on ethical values and sustainable development."

The successful example of Mondialogo highlights how public-private partnerships can build on common strengths, resources and networks of each of the partners, in Mondiallog's case UNESCO's Associated Schools network of more than 7000 schools worldwide and DaimlerChrysler's international nature with more than 362,000 employees and a presence in 200 different countries

THE L'OREAL-UNESCO PARTNERSHIP FOR WOMEN IN SCIENCE

Another successful example for such partnership and its impact is the The L'Oreal-UNESCO Partnership for Women in Science. In September 1999, L'Oreal – the French cosmetics company – and UNESCO committed themselves to a shared vision, namely "through mutual, concerted cooperation, to carry out joint projects which would benefit the situation of women on an international scale in general and in their scientific work in particular". The resulting partnership was solidified in October 2002, when the Executive Board of UNESCO officially approved the partnership programme and in particular the creation of the L'Oreal-UNESCO Prize for Women in Science.

The L'Oreal-UNESCO Partnership for Women in Science has been developed

- to distinguish eminent women scientists at the height of their careers;
- to support promising young women scientists to pursue research projects at leading institutions, usually outside their home country;
- to promote the achievements of women in science and thereby encourage more women to adopt science as a career.

Annually, a prize of US$ 100 000 each is given to five outstanding women researchers, one from each continent, selected by an independent jury presided over by Nobel Prize Laureates Christian de Duve of Belgium and Gunter Blobel of Germany. Almost two thousand eminent members of the scientific community in Life Sciences and Material Sciences (alternating each year) propose candidates for the Awards. Two separate juries – one for each scientific area concerned, consisting of up to 15 members – then select from among the nominees the winners. By 2004, 31 women scientists had received this top award, which – without too much hype – can be placed on an equal footing with the Nobel Prizes in the sciences.

In addition, each year a Selection Committee of the UNESCO-L'Oreal Fellowships chooses 15 promising young women scientists at doctoral or post-doctoral levels – three from each continent - to receive an amount of Euro 20,000 each (doubled in value from the grants awarded between 2000 and 2002) to help them continue their research projects in an institution outside their country of origin. This research is often oriented towards local issues. Since their creation, 60 young women from 42 countries have received the fellowship.

The regional spread for both the Prize Laureates and the Fellows rewards and recognizes women working under what are often greatly varying conditions. Women scientists from across the world have thus been recognized for excellence in research or received encouragement to pursue their careers.

Beyond the award of prizes and fellowships, the global partnership has spread to the establishment of complementary national initiatives, developed by L'Oreal subsidiaries and UNESCO National Commissions for UNESCO as well as UNESCO field offices. These offshoots now are operational in over 20 countries and include national fellowships for local women scientists, educational and mentoring programmes to introduce young girls and women to careers in science as well as related conferences, seminars and publications.

The partnership has already achieved considerable renown in the scientific community and with the general public. It has also received worldwide coverage by the media and has fortified its unique name recognition. The network constituted by the women laureates – prize winners and fellows alike – is called upon to play an important role wherever the future of science and its social vision is at stake.

LESSONS FOR BUILDING FUTURE PUBLIC-PRIVATE PARTNERSHIPS (PPPS)

What is the secret of successful PPPs? Judging from UNESCO's experience and my personal involvement in both the Mondialogo and L'Oreal-UNESCO partnerships, there are several factors for the success of such partnerships:

- mutual understanding of expectations and values of each partner;
- clear definition of and agreement upon of the objectives of a partnership, its expected outcomes and commonly shared values;
- a jointly-developed business plan with targets, benchmarks, agreed inputs and resource provisions;
- setting a realistic time-frame, avoiding both too ambitious and unrealistically tight deadlines;
- firm commitment of resources in terms of finance and staff;
- mobilizing proprietary networks of all partners to magnify outreach and involvement;

- regular monitoring of implementation of the business plan and application of corrective measures, where required, by a joint mechanism/steering group;
- commitment by senior management of each partner to get involved on a sustained basis (as is the case with DaimlerChrysler's and L'Oreal's CEOs and the Director-General and senior officials of UNESCO);
- public information and outreach, visibility and appeal (through goodwill ambassadors and celebrities) and successful (name) branding and visibility;
- involvement of civil society actors.

WORKSHOPS
STRUCTURE AND AIMS

104-111

A.H. ZAKRI
Director, UNU Institute of Advanced Studies (UNU-IAS)

Structure of today's sessions

Objective of today's working groups discussion:

Link major issues identified yesterday for further deliberation in the working groups

How we proceed today

1. Summary of major issues raised yesterday
2. How we proceed in the working groups

Globalization

- Globalization has become possible through science and technology
- Globalization is unstoppable, irreversible
- Globalization has been unequal, developing countries marginalized

We must shape the direction and form it takes:

- To ensure that globalization serves human interests and is of benefit to all.
- Science and technology can harm people if not directed and shaped properly.

How globalization can serve mankind

- Address human needs such as
  - drinking water,
  - energy
  - epidemics & public health issues,
  - climate change etc.

  - i.e. WEHAB from WSSD

Human needs

- Examples from Thailand
- Simple and sophisticated technologies can be used to address needs of people
- To ensure serving people, think of :
  - ethics
  - Laws and regulations
  - Prioritization of issues e.g. choice of technology, local relevance, obsoleteness
  - Economic justification

Globalization has been unequal

- Market has been globalized
- Environment and people have been out of globalization
- Science has been globalized
- Barriers to technology transfer
- Current models of technology transfer and international assistance are not working as well as many would have hoped
- Problems: biotechnological underdevelopment are trans-religious, trans-cultural and cut across the barriers of religion, language, color, gender or creed…need common solutions? One size fits all?
- Traditional knowledge?

How to bridge these inequities

- Have a more inclusive view of science and technology
- Connect science to Millennium Development Goals
- Society should be central in shaping the direction of S&T
- Science for policy and policy for science
- Policy is the major determinant in tackling poverty not technology

The way forward

- Empowering people
- Empowering countries

Empowering people

- Access to knowledge
- Ability to use / employ their knowledge effectively (do something about the brain drain)
- Evaluate current practices and propose a comprehensive overhaul of the approach to capacity building for science and technology
- Multidisciplinary? Multisectoral? approach

Empowering countries

- Formulation of appropriate policies; training of policy makers
- Create a critical mass of scientists
- Investment/funding in science and technology
- Create well-functioning and inclusive education system
- Facilitate global knowledge exchange
- Strengthen linkages between institutions of higher education
- Strengthen industry, government and private research institutes linkage

Empowering countries

- Formation of a holistic national innovation network
- Develop effective and replicable capacity-building strategies
- Scientific and technological capacity specifically targeted to addressing regional challenges
- Promote both South-South and North-South collaboration
- Utilize the talents of female researchers and scientists

Areas of action

- Common actions to tackle common problems
- Effective collaboration and cooperation among organizations and people
- Link national strategies with global development goals e.g. MDGs
- Ownership as a principle in international cooperation
- Priority areas? E.g. ICT, biotechnology, nanotechnology, material science etc.

Example of Japan

- A nation, poor in natural resources, that has built its economy on science and technology
- Government commitment and heavy investment in science and technology
- Cooperation with neighboring countries on science and technology is a strategic objective in Japanese government planning
- Two examples of cooperation:
  - Okinawa Institute of Science and Technology
  - STS forum

How we proceed in the working groups

General Guidelines

- Rapporteurs have been assigned to every working group to assist the chair person in preparing a report on the conclusion.
- Each working group will have two sessions: two hours in the morning (11:00-13:00), and an hour and half (14:30-16:00) in the afternoon of 24th August. In total, each working group will have three hours and half for its deliberations.

General Guidelines

- Each working group has a designated chair person, two rapporteurs, and in principle three invited speakers.
- Invited speakers are expected to speak for about 20 minutes each in the morning of August 24th. After their presentations, the discussion starts in the morning session (about 1 hour), leading to a conclusion in the afternoon session

General Guidelines

- The session in the afternoon of August 24 (1.5 hours) is dedicated to questions and answers, discussion, and drafting of conclusions
- Each chairman is expected, with the help of the rapporteurs, to submit to the plenary at 16:30 on the 24th August, a short report that could be elaborated for the planned publication of the conference.

General Guidelines

The report should highlight

1. The main points of discussion
2. Specific trends
3. Challenges and opportunities
4. The role of UN system, in particular that of UNU and UNESCO
5. Specific proposals for future actions

WORKSHOP SESSION 1
KNOWLEDGE-SHARING

Andrew Barde GIDAMIS

Executive Secretary
African Institute for Capacity Development (AICAD), Kenya

As head of AICAD, Andrew Barde Gidamis coordinates research, training programmes, and information networking among public universities in East Africa, and liaises on AICAD programmes with the governments of East African countries and the government of Japan (through the Japan International Cooperation Agency). Prior to joining AICAD in 2003, he spent 18 years with the Department of Food Science and Technology, Sokoine University of Agriculture (Tanzania), including serving for six years as department head. Prof. Gidamis has published extensively in peer-refereed academic journals. He holds a PhD in Agriculture from Kyoto University (Japan).

ENHANCING INFORMATION AND KNOWLEDGE SHARING FOR POVERTY REDUCTION

ENHANCING INFORMATION AND KNOWLEDGE SHARING FOR POVERTY REDUCTION IN AFRICA: AICAD EXPERIENCE

A Paper Presented at the International Conference on Globalization: Challenges and Opportunities for Science and Technology held in Yokohama, Japan 23-24 August 2006

by

Prof. Andrew B. Gidamis
Executive Director
African Institute for Capacity Development (AICAD)
P. O. Box 46179, Nairobi, Kenya

CONTENTS

Globalization: the Term and System

- Globalization implies a world systems developed extensively between nations
- *The term came into common usage in the 1980s, though in reality it is as old as mankind*
- *It has revolutionized all aspects of human life worldwide: trade, markets, access and flow of information, international justice, political and cultural integrations*

Globalization: the Term and System cont'd

- It is both a source of repression and a catalyst for global social justice and emancipation
- It embraces many disciplines both in temporal and spatial dimensions
- It poses many contradictions, variations, and interpenetrations to those who attempt to understand it
- Among many forms of globalization there is information and knowledge access and sharing

Globalization, Knowledge and Information Sharing

- **For long time information and knowledge were silent in globalization players at national and international levels**
- **To date information and knowledge access and sharing are the most globalized**
- **Advances in** ICT, **knowledge and information sharing have catalyzed globalization process making the world a "global village"**

Globalization, Knowledge and Information Sharing **Cont'd**

- Information and knowledge access have enhanced economic, political and cultural globalization
- Without sufficient information access and sharing other forms of globalization are bound to make slow progress or even fail
- With ICT markets and advertisement are sought and done globally in e-commerce
- ICT has high potentials of making globalization succeed faster than otherwise expected

Information and Knowledge Sharing In Africa

- Globalization extends its economic forces to all parts of the world controlling means of production and marketing mechanisms
- In this way no part of the world, including Africa is left out
- Africa is therefore part and parcel of globalization
- However, Africa's involvement in globalization is at a great disadvantage considering ICT as major player in globalization

Information and Knowledge Sharing In Africa Cont'd

- Due to lack of sufficient ICT elements to participate fully Africa finds itself on the periphery of globalization development
- The limited ICT activities Africa participates in, exposes it to uncontrolled exploitation
- Africa's lack of ICT does not only mean it misses out on sharing world information, but also fails to share its own information and knowledge.

Sharing indigenous Information and knowledge in Africa

- Africa is not short of indigenous information, knowledge and technologies to address the odds of poverty
- However, it is short of means to harness, organise, control and share its indigenous information and knowledge
- Indigenous communities participate in research by providing data but are never given relevant feedbacks
- In some cases the feedbacks given to them by experts are highly sophisticated and technical and as such could not be easily applied by local communities

Sharing indigenous Information and knowledge in Africa Cont'd

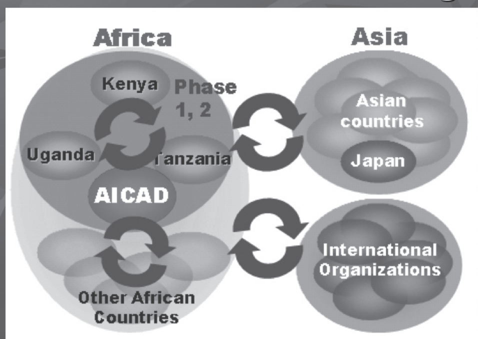
- The delivery methods tend to be autocratic without room for the input from the communities.
- This leads to failed communication and in most cases rejection to new knowledge by the communities
- Failed communication leads to more knowledge and information gaps and in such cases poverty deepens due to failed interventions.

Sharing indigenous Information and knowledge in Africa Cont'd

- Horizontal information and knowledge sharing among peers, seems to work well, but not vertically
- For vertical information and knowledge sharing to succeed between grassroots and experts and vice versa, experts have to respect grassroots inputs and tolerate their views
- The failures in communication is largely responsible for the contradictions and the prevailing poverty patterns in Africa

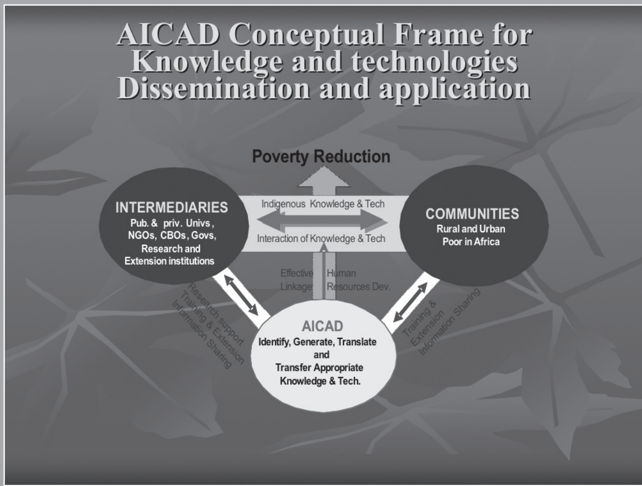
AICAD contributions to information/knowledge sharing in Africa-AICAD Location

AICAD contributions to information/knowledge sharing in Africa-AICAD Networking

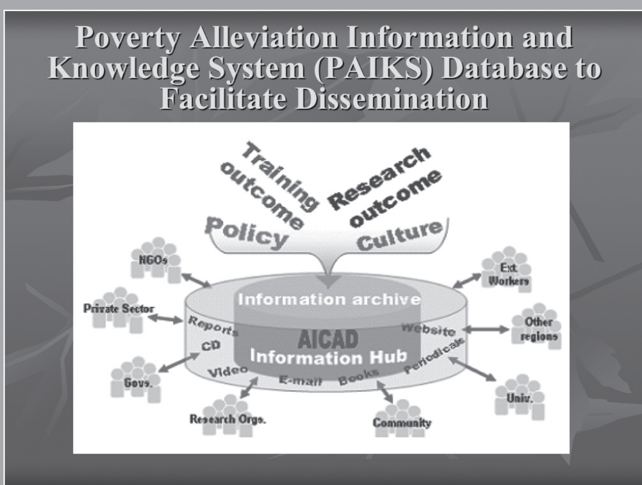


AICAD contributions to information sharing in Africa- Approach

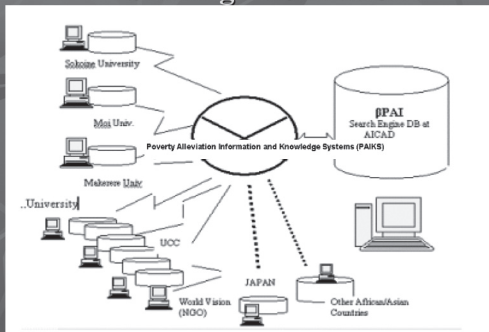
- AICAD aims at poverty reduction through human capacity development through:
  - Research and Development in unveiling missing links in information, knowledge and technologies
  - Training and Extension to impart information and technologies into grassroots for poverty reduction
  - Information, Networking and Documentation to facilitated dissemination and sharing to empower communities
  - Intermediaries to interpret information in appropriate communication media to grassroots
  - Grassroots to implement the information, knowledge and technologies application activities for poverty reduction


AICAD Conceptual Frame for Knowledge and technologies Dissemination and application
Poverty Reduction
INTERMEDIARIES
Pub. & priv. Univs, NGOs, CBOs, Govs, Research and Extension institutions
Indigenous Knowledge & Tech
Interaction of Knowledge & Tech
COMMUNITIES
Rural and Urban Poor in Africa
Effective Linkage
Human Resources Dev.
Research support
Training & Extension
Information Sharing
AICAD
Identify, Generate, Translate and Transfer Appropriate Knowledge & Tech.
Training & Extension
Information Sharing


Training and Extension Activities At Regional and Country Levels
Community Needs
Regional Training
In-Country Workshop
In-County Seminar
Extension
The In country and Regional courses

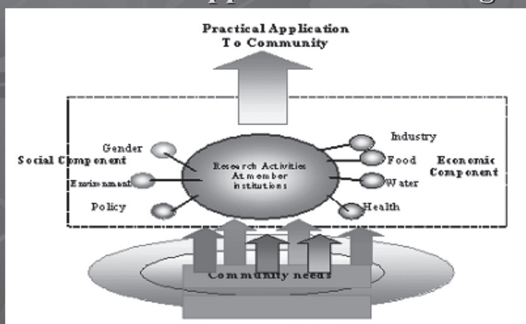

Poverty Alleviation Information and Knowledge System (PAIKS) Database to Facilitate Dissemination
Training outcome
Research outcome
Policy
Culture
NGOs
Ext. Workers
Private Sector
Information archive
Reports
CD
Video
E-mail
Books
Periodicals
Website
AICAD
Information Hub
Other regions
Govs.
Univ.
Research Orgs.
Community

Database in a Portal Arrange for Sharing information



Poverty Alleviation Information and Knowledge Systems (PAIKS)

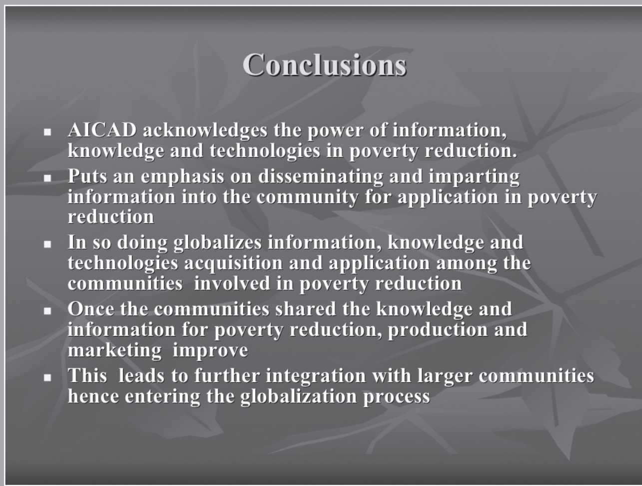
Research Model Showing Researchable Areas and Application of Findings



Socio-economic impact through research initiatives

AICAD activities at the Grassroots

- The Intermediaries comprise experts from Universities, Research Institutions Government Departments, NGOs, IGOs, INOs, CBOs, FBOs, Extension Workers and Community Opinion Leaders.
- AICAD coordinates experts' work among the communities to develop human capacity to reduce poverty


Conclusions
AICAD acknowledges the power of information, knowledge and technologies in poverty reduction.
Puts an emphasis on disseminating and imparting information into the community for application in poverty reduction
In so doing globalizes information, knowledge and technologies acquisition and application among the communities involved in poverty reduction
Once the communities shared the knowledge and information for poverty reduction, production and marketing improve
This leads to further integration with larger communities hence entering the globalization process


Acknowledgements
Finally on behalf of AICAD and on my own behalf I wish to thank the United Nations University (UNU) and UNESCO for the invitation and support to attend this important workshop on Globalization and present AICAD experience in facilitating information and knowledge sharing in Africa.
Thank you

Luc SOETE

Director
UNU Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT)

Luc Soete is Professor of International Economics (on leave) at the University of Maastricht (The Netherlands). He previously worked at the Centre for Development Studies, University of Antwerp (Belgium); Institute of Development Studies and Science Policy Research Unit, University of Sussex (UK); and Department of Economics, Stanford University (USA). He is a member of the Dutch advisory board on science and technology. Prof. Soete holds a D.Phil. degree in Economics from the University of Sussex. His research interests are focused on the impact of technological change (in particular, new information and communication technologies) on growth and development.

KNOWLEDGE SHARING: A GLOBAL CHALLENGE [1, 2]

ABSTRACT

While there remains a huge concentration of knowledge production activities in the developed countries, the last twenty years have seen a major shift in worldwide access to codified knowledge. The role of information and communication technologies has been instrumental here, as has been that of more capital and organisational embedded forms of technology transfer such as foreign direct investment. Today one of the most important enabling features for development is knowledge access. Access is, however, not required to knowledge under such codified or capital embedded forms alone, but also to the tools and (legal) ability to replicate and improve upon knowledge. For developing countries it is no longer access to knowledge as passive producers/ consumers which fitted well with the old development model where developing countries would be treated as consumers who would not have the ability to innovate or, if more industrially advanced, would imitate production methods developed elsewhere. The cases reviewed in the paper show that while access to codified knowledge may build skills through passive absorption (e.g. through textbooks), access to technology in a form that can be shared and modified without entry barriers can build advanced skills and compensate for the absence of formal training. While access to knowledge as a passive process is politically framed within the language of development aid, access to technology as a way of providing the right and ability of participation is analogous to the arguments favouring free trade: developing countries can then be seen as providing a resource of potential innovators, rather than merely using existing innovations from the developed world.

INTRODUCTION

Economically, the last fifty years the world has witnessed an unparalleled growth and transformation. Economic development has undoubtedly been spurred by the opening up and ensuing expansion of world trade and the dramatic reduction in barriers to capital movements, but it would only be fair to say that either in conjunction with such liberalisation or separate from it, the growth externalities of knowledge have had a lot to do with the rapid post war growth. First under the form of a straightforward process of catching up of Western European countries and Japan to levels of productivity and consumption of those of the United States – known in Europe as the thirty glorious years ("trente glorieuses" from Jean Fourastier, 1979) – and subsequently a somewhat similar process in the case of the so-called newly industrialising South East Asian economies. The third phase set in motion in the late 90's with the world integration of large emerging economies such as Brazil, Russia, India and China (the so-called BRICs) – compared by Richard Freeman (2005) with a doubling of the world labour force – could be said to be still in full swing requiring a much longer period of global adjustment, according to Freeman some thirty years.

Innovation and the rapid shifts in global demand play in other words today a much more crucial role in the policy debates about science and technology. The largest part of world wide growth and development has undoubtedly been associated with an acceleration in the diffusion of technological change and world wide access to codified information. The role of information and communication technologies has been instrumental here as has been that of more capital and organisational embedded forms of technology transfer such as foreign direct investment which is today as a percentage of GDP a decimal point greater than what it was fifty years ago and no longer limited to the OECD world. By contrast, labour markets and with them the knowledge embodied in skills and human capital have barely globalised, with the exception of the mobile top tail of scientists, engineers, managers, actors, football players or other creative talent.

In short, while ICT technologies enable easier diffusion of information, the global knowledge market (if there is such a thing) and with it global access to knowledge – and in particular in its creation – remains highly unequal. There remains a continuing concentration of innovative activities in a small number of regions in the world which are matched by persistent international differences in the share of resources devoted to science and technological efforts. Yet, today it is no longer the direct impact of the transfer of industrial technologies on economic development which is at the centre of the debate but rather the broader organisational, economic and social embedding of such technologies in a development environment and the way they unleash or block particular specific development and growth opportunities. That process is in all likelihood much more complex in a developing country context than in a developed country one. As has become recognized in the endogenous growth literature[3], the innovation policy challenge with its characteristic Schumpeter mark 1 versus mark 2 features appears closely associated with actual levels of development. In the high income, developed country context the innovation policy challenge seems increasingly directed towards questions about the sustainability of processes of "creative destruction" within environments that give increasingly premiums to insiders, to security and risk aversiveness, and to the maintenance of income and wealth. In an emerging, developing country context, by contrast, the challenge appears directed towards the more traditional, "backing winners", industrial science and technology policies bringing also to the forefront the importance of engineering and design skills and accumulating "experience" in particular. Finally there are those poor countries characterized by "disarticulated" knowledge systems, well described by many development economists in the area of science and technology (Martin Bell, 1984, Francisco Sagasti, 2004) and where the endogenous innovation policy challenge is probably most complex of all.

THE INDUSTRIAL CATCHING UP PARADIGM: THE IMPORTANCE OF CUMULATIVE, TECHNOLOGICAL EXPERIENCE ACCUMULATION

The national industrial S&T systems in developed countries and in the US in particular has been well described by many scholars in the area of the economics of technological change and innovation studies[4]. Such studies have brought to the forefront the importance of some core institutions: the university and private industrial R&D, the importance of experimental development work, design, and engineering experience. What became characteristic of industrial production was, as many of the Sussex more sectorally focused innovation studies from Christopher Freeman, Keith Pavitt and Giovanni Dosi have demonstrated in detail, the activity of industrial R&D, its scientific content and the extent of professional specialisation accompanying it. It is this sort of professional work which became and still is recorded in official, internationally harmonized R&D statistics. As was actually already acknowledged in the early days of defining what was to become the Frascati Manual definition of "R&D", the industrial R&D statistics were first and foremost a reflection of the professionalisation of R&D activities. In many manufacturing firms the "technical" or "engineering" departments or "OR" sections contributed far more to the technical improvement of an existing process than the formal R&D department, more narrowly defined. But the emergence of the particular R&D function was what came to be most closely identified with the emergence and growth of the industrial society.

As historians have argued this industrial research "revolution" was not just a question of change in scale. It also involved a fundamental change in the relationship between society on the one hand and technology and science on the other. The expression "technology", with its connotation of a more formal and systematic body of learning, only came into general use when the techniques of production reached a stage of complexity where traditional methods no longer sufficed. The older, more primitive arts and crafts technologies continued to exist side by side with the new "technology". But the way in which more scientific techniques would be used in producing, distributing and transporting goods led to a gradual shift in the ordering of industries alongside their "technology" intensity. Thus, typical for most industrial societies of the 20th Century, from Japan, to Europe and the US, there were now high-technology intensive industries, having as major sectoral characteristic the heavy, own, sector internal R&D investments and low-technology intensive, more craft techniques based industries, with very little own R&D efforts. And while in many policy debate, industrial dynamism became as a result somewhat naively associated with just the dominance in a country's industrial structure of the presence of high-technology intensive sectors, the more sophisticated sectoral studies on the particular features of inter-sectoral technology flows, from Pavitt (1984) to Malerba (2004), brought back to the forefront many of the unmeasured, indirect sources of technical progress in the analysis.

FROM INDUSTRIAL R&D TO INNOVATION TO COLLABORATIVE OWNERSHIP: A PARADIGM SHIFT?

The 90's brought though a significant shift in one's understanding of the relationships between research, innovation and socio-economic development. The perception of the nature of innovation processes changed significantly. Innovation capability became seen less in terms of the ability to discover new technological principles, but more in terms of the ability to exploit systematically the effects produced by new combinations and use of pieces in the existing stock of knowledge (David and Foray, 2002). The new model, closely associated with the emergence of numerous knowledge "service" activities, implied more routine use of a technological base allowing for innovation without the need for particular leaps in science and technology, sometimes referred to as "innovation without research". It requires a systematic access to the state-of-the-art technologies; whereby industries introduce procedures for the dissemination of information regarding the stock of technologies available, so that individual innovators can draw much more directly upon the work of other innovators. This mode of knowledge generation -- based on the recombination and re-use of known practices -- raises more information-search problems and is more directly confronted with the problems of impediments to accessing the existing stock of information that are created by intellectual property right laws.

This shift in the nature of the innovation process seems to imply a more complex, socially distributed structure of knowledge production activities, involving a much greater diversity of organizations having as explicit goal knowledge production. The old industrial system was based on a relatively simple dichotomy between knowledge generation and deliberate learning (R&D laboratories, engineering and design experience) and activities of production and consumption where the motivation for acting was not to acquire new knowledge but rather to produce or use effective outputs. The collapse (or partial collapse) of this dichotomy leads to a proliferation of new places having the explicit goal of producing knowledge and undertaking deliberate research activities, which may not be readily observable but nevertheless essential to sustain innovative activities in a global environment.

In short, traditional R&D-based technological progress, still very much dominant in many industrial sectors ranging from the chemical and pharmaceutical industries to motor vehicles, semiconductors and electronic consumer goods has been characterized by the S&T system's ability to organise technological improvements along clear agreed-upon criteria and a continuous ability to evaluate progress. At the same time a crucial part of the engineering research consisted, as Richard Nelson put it, "of the ability to hold in place": to replicate at a larger industrial scale and to imitate experiments carried out in the research laboratory environment. As a result it involved first and foremost a cumulative process of technological progress: a continuous learning from natural and deliberate experiments.

The more recent mode of technological progress described above and more associated with the knowledge paradigm and the service economy, with as extreme form the attempts at ICT-based efficiency improvements in e.g. the financial and insurance sectors, the wholesale and retail sectors, health, education, government services, business management and administration, is much more based on flexibility and confronted with intrinsic difficulties in replication. Learning from previous experiences or from other sectors is difficult and sometimes even misleading. Evaluation is difficult because of changing external environments: over time, among sectors, across locations. It will often be impossible to separate out specific context variables from real causes and effects. Technological progress will in other words be much more of the trial and error base yet without as in the life sciences providing "hard" data, which can be scientifically analysed and interpreted. The result is that technological progress will be less predictable, more uncertain and ultimately more closely associated with entrepreneurial risk taking.

If this first shift in one's understanding of innovation involved removing the dichotomy between R&D and production, a second shift has been occurring more recently, removing (partially) the distinction between production – as a locus for innovation – and consumption. The notion of user-driven innovation has been used to explain the rise of open source software as well as some other sectors such as sports equipment by Von Hippel (2004). Such innovation reduces risks for individual entrepreneurs, as the risk of developing an unsuccessful technology is spread across the many user-producers who contribute and perhaps implement their own ideas.

More broadly, blurring the distinction between production and consumption allows one to understand the increasing importance of collaboration among multiple producer-consumers, with incremental innovation contributed by several producers resulting in a single end-product. The more complex the interaction is among contributors, the more sophisticated can be the innovation, as resources and skills can be matched to needs with lower search and transaction costs. This may require adjustments in attitudes to ownership and the control of rights. This form of collaborative ownership and production (Ghosh, 2005) can be found in several domains beyond software, and is strikingly similar to Allen's notion of collective invention (Allen, 1983). It is to a more detailed description of some of those features that we turn now focusing in particular on software and the emergence of open source software.

OF SOFTWARE AND STEAM ENGINES

Open Source Software is the most obvious instance of such collaborative ownership and production. It has previously been argued that such collaboration in the production of non-rival information goods in particular takes place in the form of implicit exchanges, or the "cooking-pot market" (Ghosh 1998): the one-time cost involved in the creation of a single intellectual work (or the making of single a contribution to a larger work) is provided in exchange for access to a diversity of works created by others (or contributions by others to the larger work). Key to this notion of exchange is the elimination of a producer-consumer barrier, the elimination of any distinction between an inventor and the user of the invention. Such a distinction is inherent in a model that rewards inventors through the allocation of exclusive rights attached to their invention. While theoretically rewarding inventors, it also creates barriers to collaborative production by making it harder for others to incrementally innovate, as others are assumed to be mainly consumers rather than possible producers.

Without inventors' exclusive rights to a product, all consumers are potentially producers of improved versions of the product. This is what happens in the cooking pot market, where, to take the example of open source software, the creator of a piece of software does not retain exclusive rights[5] but allows others to improve upon it. The person with the best skills or understanding of needs can innovate; innovation is no longer limited to the original creator of a work. This implies the (near) elimination of search costs involved in identifying the best skills and resources to improve a work, as well as the elimination of transaction costs that would be required under an exclusive rights and royalty licensing regime.

A historical example of how such collaboration can work in other domains is provided by Nuvolari (2005) who draws explicit links between the model of open source software production and the development of the Cornish pumping engine. He notes that the steam engine patented by Watt was sold extensively among Cornwall mines, which accounted for between 28 and 80 per cent of Boulton & Watt's business in the first half of their patents lifetime[6], from 1769 to the mid 1780s. The Cornish businesses did not like the Boulton & Watt royalty model and challenged the patent for its broadness (it covered all engines using steam as a "working substance"; this allowed Watt to block advances in engine technology by other inventors). They lost and were forced to continue paying royalties till the end of the patent in 1800, at which time "steam engine orders to Boulton & Watt from Cornish mines ceased completely".

Shortly afterwards, Nuvolari notes that Cornish businesses collectively started publishing a monthly journal, Lean's Engine Reporter, reporting the technical characteristics, operating procedures and performance of each engine built – the engines' "source code", as it were – leading to collaborative improvements based upon the knowledge that was now public. Nuvolari shows that "the practice of information sharing resulted in a marked acceleration in the rate of technical advance", and this had an effect on the innovation culture much as the success of open source has a effect on the behaviour of its participants. Richard Trevithick did not patent his 1812 engine. Another Cornish inventor, Arthur Woolf, patented one major invention which found no purchase among Cornish businesses used to "open source" sharing; he chose not to patent his next invention.

Cornwall was a major source of innovation in steam engines, and Nuvolari shows that while it had a significant share of all UK patents filed from 1698 to 1812, in its period of "open source" innovation during the publication of Lean's Engine Reporter, when the Cornish pumping engine was actually developed, the county's share of national patents was almost zero.

The cases of steam engines and software, while very different in terms of modes of production, consumption and pace of innovation, have one thing in common: an awareness among participants in the market that innovation can be driven by widespread access to the ability to replicate and improve, in explicit contrast to the restricting of this ability by exclusive rights awarded to individual innovators. Even in terms of reward and business models, there are similarities – there is a clear parallel between software as a cost rather than profit centre in today's economy and the steam engine as a cost centre for mining businesses, who earned profits from mining not engine building. Similarly, the case of mining entrepreneurs awarding prizes for desired innovations that would be made publicly available recall the open source software "bounties" from the South African businessman Mark Shuttleworth[7] and prizes for public healthcare proposed by Hubbard and Love (2005).

In the case of steam engines, certainly, the pace of technical innovation through this "open source" process of collaborative ownership[8] was higher than the "proprietary" approach that preceded and followed it. In the case of software, it is perhaps too early to tell, but clearly the software and mode of collaboration has received enormous support from businesses.

NEW ARRANGEMENTS FOR INNOVATION

The collaborative forms of ownership and production described above do not need to have any formal arrangements between contributors. In the case of the Cornish miners, there was mainly social pressure resulting from a recognition of the value of collaboration, combined with some resentment towards patenting due to earlier experiences with the Boulton & Watts business model.

However, collaborative production does raise questions of rational expectations and free-riding. Participants are likely to contribute if they can reasonably expect matching contributions from others. Such contribution may be negatively affected if too many are seen to free-ride. This should be qualified: creators of non-rival knowledge and information goods may realise that "free-riding" in terms of consumption of such goods is not purely negative, unlike the "tragedy of the commons" involving grazing grounds (Hardin 1968). Creators of knowledge goods realise that readers or users can be valuable in themselves (Ghosh 1995) and indeed the size of the user base is the common criterion for valuations among venture capitalists in new Internet businesses (e.g. Francisco 2006).

Frameworks, formal or informal, may thus be helpful for the existence of collaborative ownership, from its inception in a particular domain of production, to its successful operation. In a Hobbsean world, implicit in many economic models, people are reluctant to collaborate with others since they assume that they will be taken unfair advantage of. Exclusive appropriation of production and its distribution under careful control is seen as the natural remedy. However, as real world examples from open source to steam engines to bioinformatics (below) show, there may be many things that help collaboration that are not always explicit, which provide an environment of preference for contribution to the commons rather than exclusive appropriation.

There is, first, the expectations of participants. If they find themselves in an environment where collaboration "just happens" – in particular, where contribution rather than exclusive appropriation is somehow rewarded – then they are likely to assume that their own contributions will also be rewarded. There may be a number of reasons why collaboration is taking place to begin with, but these are not necessarily analysed by new participants. Thus, the reasons for previous participants' preference for contribution over exclusive appropriation may be diffuse and even, for some, irrational, but need not affect the behaviour of new participants (see Ghosh et al 2002 for an empirical exploiration of the motivation of open source developers).

The environment that shapes expectations is underpinned by social norms that have formed within communities of collaboration. Open source arose out of the norms developed in two closely related communities – that of software developers (especially academics) in the 1970s and mid 1980s (Levy 1984; Himanen 2001), and that of on-line communities of the late 1980s and 1990s (Turkle 1995). The latter in particular was notable for providing an environment for the development of pseudolegal rules and social norms that defined behaviour in several on-line communities.

Many descriptions of the free software community, and other collaborative but non-monetary production on the Internet, borrow the notion of "gift-giving" that (hypothetically) occurs in "tribal" societies (e.g. Barbrook 1998). An assumption is that free software production is similar to supposedly primitive forms of interaction involving the generous contribution of gifts with no expectation of returns – altruism in the sense that economists use the term.

There are indeed similarities between collaborative production and non-monetary exchange in tribal societies and collaborative ownership in the digital economy, notably free software: both are based on the self-interested participation of individuals and communities linked by a complex web of rights and obligations. In particular, there are numerous counter-examples to the simplistic IPR model of exclusive appropriation, which recognizes only individual (rights-based) and collective (public domain) ownership of works. Certain communities of Papua New Guinea exhibit the imagined collective (Strathern 2005) which represents not true collective ownership (where everyone is the joint owner of a single work) as much as multiple authorship or multiple ownership, where each "owner" lays claim to a certain definable but inseparable part of a collectively owned whole.

This is not gifting. Nor is it exclusive appropriation. This form of ownership lies somewhere between individual appropriation (individual works map to individual authors) and the commons (the entire work maps collectively to the entire set of authors). Whether Papuan Tambarans described by Leach (2005), or the source code of the Linux Kernel, the core of the most successful open source software system – individual contributions have no value independent of the context of the whole (collaboratively produced) work of which they form a part. Yet, individual contributions can be clearly identified. In the case of the Linux Kernel (Ghosh and David 2003), each individual line of source code is "owned" by its individual creator (thanks to copyright law, which makes explicitly claiming ownership unnecessary) and also identifiably associated with its creator (thanks to the version-control tools used to enable collaborative development of Linux). Under copyright law, the Linux is not collectively owned by any means; no single group owns the copyright to the entire work. Indeed, as discussed in a later section, this distribution of ownership is a major guarantee of the sustained "freeness" of Linux, as there is no single – individual or collective – owner able, for example, to sell the rights to a commercial entity for exclusive appropriation. Contrast this with a scientific paper where all joint authors collectively own the entire paper.

The Linux Kernel is not, however, in the public domain, or even in a commons – each individual contribution can be associated with its individual contributor who, in terms of copyright law, owns it. However, the individual and individually owned contributions only make sense, and have any value at all, in the context of the combined whole – which is, hence, multiply owned.

This is possible in open source software thanks partly to social norms similar to those of the Cornish engineers – awareness of the benefits of collaboration and a certain antipathy towards proprietary forms of development (Ghosh et al 2002). But what ensures the success and sustainability of open source is the legal infrastructure behind much of it[9]. This is exemplified by the GNU General Public License or GPL[10], a copyright licence that ensures reciprocity: users are free to modify and share software contributions, but only under the same terms. This ensures that improvements to software remain available to previous contributors (providing them an incentive to make the initial contributions in the first place) and to future contributors (ensuring sustainability of innovation in the software). This results in innovation taking place not in the public domain, but in a "protected commons" (Aigrain 2002).

Other sectors of industry have picked up on this arrangement of semi-voluntary reciprocity to create a protected commons, for example in the area of genomics. The ENSEMBL project (Hubbard et al 2002) is a public database of human genome sequences with annotation. Human genome sequences are identified by various researchers, publicly and privately funded, but are not very useful without annotation placing them in context and identifying their purpose. Those who identify a sequence may not be interested (or have resources) to annotate, or further exploit a given sequence. There is a clear problem of high search costs to match those with the need to work on a sequence to those who have identified or explained the sequence. Thus, participants agree to make annotations and other contributions public. Needless to say, the system runs on sophisticated software developed as open source.

The SNP consortium "was established in 1999 as a collaboration of several companies and institutions to produce a public resource of single nucleotide polymorphisms (SNPs) in the human genome. The initial goal was to discover 300 000 SNPs in two years, but the final results exceeded this, as 1.4 million SNPs had been released into the public domain at the end of 2001" (Thorisson and Lincoln 2003). It is funded by contributing firms including most of the major pharmaceutical firms and several major software developers[11]. Firms commit to make their contributions publicly available, recognising that it is easier to build private developments upon a jointly developed public resource rather than to duplicate efforts. More closely related to open source software in terms of its incentives structure is the HapMap project (International HapMap Consortium 2003), a successor to the Human Genome Project that aims to identify common patterns of variation within the genome. HapMap imposes reciprocal requirements in the form of a protected commons for research in progress; however, once the project is finally completed, results will be released to the public domain with no reciprocity requirements.

The examples above should demonstrate that there is a degree of innovation within the process of innovation itself, and thus the instruments of promoting it – exclusive rights granted to single economic actors for individual innovations – may not always be the most appropriate. Other arrangements for enabling collaborative innovation have been developed and are being applied in a number of domains; they may be useful to investigate further.

CONCLUSIONS: INNOVATION AND DEVELOPMENT

The implications of these new modes of technological progress for development are rather striking. First and foremost they bring to the forefront the importance of endogenous innovation processes in developing country situations. In the old industrial S&T model, the focus within a context of development was quite naturally on technology transfer and imitation. Imitation as the opposite of innovation. Allowing for a sudden and rapid catching up process being accompanied by a systematic copying or where necessary the adoption of appropriate technologies from developed countries. In the new mode every innovation is to some extent unique with respect to its application. Re-use and re-combinations of sometimes routine, sometimes novel pieces of knowledge might be of particular importance. International access to knowledge is essential though and so are recombination skills.

If one looks at the common feature described previously for various examples of collaborative innovation, the most important enabling feature is access. Access is not required to knowledge alone, but to the tools and (legal) ability to replicate and improve upon knowledge. Thus it is not access to knowledge as passive consumers, which is often discussed and fitted well with the old model of R&D distinct from producers distinct from consumers. In the old model, developing countries are often treated as consumers who do not have the ability to innovate, perhaps due to the lack of technical skills, and must therefore passively consume products of developed countries (with subsidies, if required) or if they are more industrially advanced they may imitate production methods developed elsewhere. Apart from being patronising, this view does not fit with the new mode of technological progress for development, for two reasons.

First, empirical research has shown (Ghosh and Glott 2005) that in the case of software, open collaboration provided by access to modifiable technology may not be problematic due to a lack of skills; rather, it leads to the development of technical, business and legal skills. Such skills are often better than those learnt in formal courses and proven participation in open source development may compensate for the lack formal degrees. These results were supported by employers surveyed. This shows that while access to knowledge may build skills through passive absorption (e.g. through textbooks), access to technology in a form that can be shared and modified without entry barriers (as with open source software) can build advanced skills, compensate for the absence of formal training and generate increased employment.

Second, the premise of the new mode of technology development is that lowering entry barriers for the modification of technology reduces search costs, allowing participants in the market of producer-consumers to more efficiently allocating skills and other resources to needs for improvement. This leads to more efficient and perhaps faster technical innovation, with the entrepreneurial risks of innovation spread widely. Thus, providing access to technology need not be seen as charity or aid for developing countries, but as enlarging the resource base of potential innovators.

While access to knowledge as a passive process is politically framed within the language of development aid, access to technology as a way of providing the right and ability of participation is analogous to the arguments favouring free trade[12]: developing countries can then be seen as providing a resource of potential innovators, rather than merely using existing innovations from the developed world.

The consequences of this shift can be significant, not only for development itself, but also for the debate concerning migration affecting the developed world today. If it becomes easier for people from developing countries to reproduce, improve and build upon innovations from the developed world, it may ease the "brain drain" of people whose only chance of exercising their potential as innovators is to emigrate.

Notes

1 , 2. Paper prepared for the UNU/UNESCO International Conference on Globalization: Challenges And Opportunities For Science And Technology, 23 and 24 August 2006, Yokohama, Japan by Rishab Ghosh and Luc Soete, respectively senior research fellow and director of UNU-MERIT, University of Maastricht, The Netherlands.

3. This view of the philosophy and aims of innovation policies differing amongst countries according to their level of development, reminiscent of many of the arguments of the old infant industry type arguments has now become popular in the endogenous growth literature. See Aghion and Howitt (2005).

4. See also the textbook on The Economics of Industrial Innovation by Chris Freeman and myself, MIT Press, 1997.

5. In fact all creators and contributors to open source initially hold copyright over their work, but allow others to modify it through the use of innovative copyright licences that waive most copyrights.

6. The patent's life was extended by an Act of Parliament to 31 years thanks to Boulton and Watt's lobbying, which shows that businesses that benefit from IPRs have long had an influence over lawmaking more than their benefit to society would justify.

7. Now provided also by others such as Google, and public markets such as Open Source Bounties http://www.opensourcexperts.com/bountylist.html

8. Nuvolari notes that contemporary literature referred to "Cornish" engines, acknowledging the collaborative character of their development

9. about two-thirds of open source software is licensed under the GPL or similarly "reciprocal" copyright licences such the LGPL or MPL. The rest is licensed under "permissive" licences that are similar to public domain copyright grants and rely only on social norms and economic incentives rather than legal controls to ensure contribution from software beneficiaries (see e.g. statistics from one of the largest software repositories, Freshmeat 2006).

10. See Wikipedia's entry on the GPL, http://en.wikipedia.org/wiki/GPL

11. See the SNP consortium website for a current list of sponsors: http://snp.cshl.org/

12. In the case of exclusive rights protection for intellectual works, this analogy has often been made explicit: in 1851 The Economist criticized patents as a barrier to trade.

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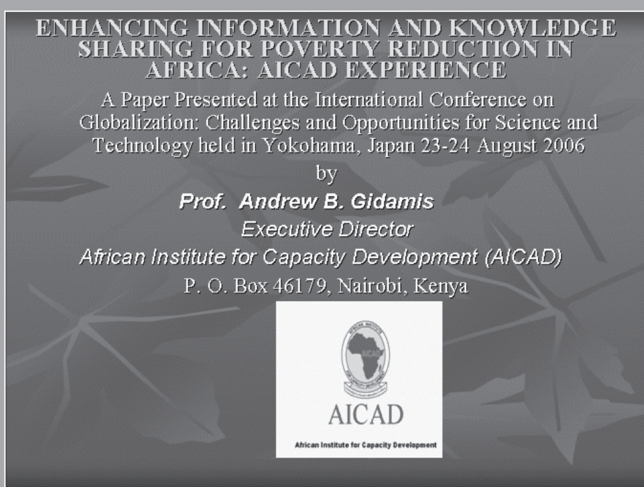
WORKSHOP 1 REPORT
KNOWLEDGE SHARING



Knowledge sharing:

A Global Challenge

Luc Soete
UNU-MERIT

UNU/UNESCO Intrenational Conference: *Globalization: Challenges and Opportunities for Science And Technology*, 23rd-24th August 2006, Yokohama, Japan.

UNITED NATIONS UNIVERSITY
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Points to be highlighed

- Main points of discussion
- Specific trends, challenges and opportunities in the themes discussed at the workshops
- Specific proposals for future actions
- Roles of the UN system, in particular UNESCO and UNU

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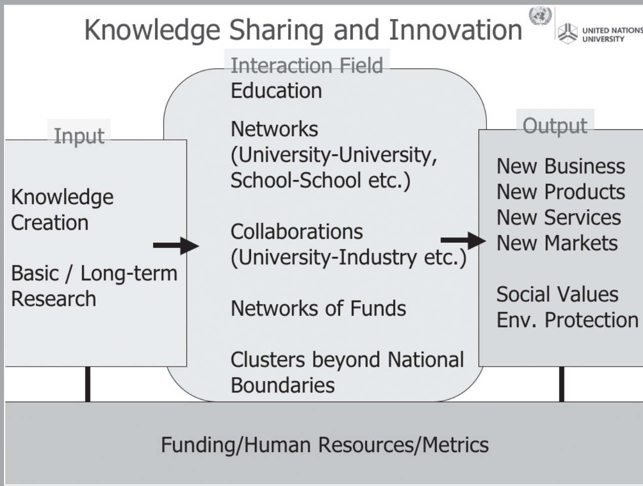
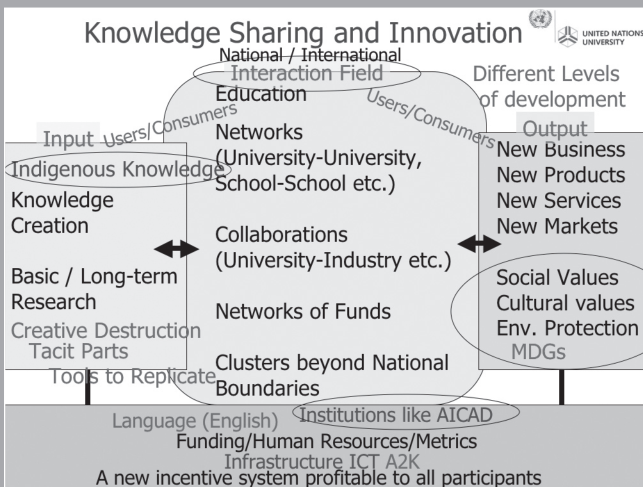
Points to be discussed

- Impact of globalization on knowledge generation and sharing.
- Innovative modalities on knowledge sharing between developed and developing countries*, and most specifically, on how to link knowledge generation and transfer to socio-economic development priorities in developing countries.*
- The impact of the opening of markets on S&T developments in developing countries.
- Suggestions on how to convert brain-drain into brain-gain.
- Innovative ideas on the role of Knowledge in (human) development (transfer, preservation and sharing of knowledge).
- Roles of the UN system, in particular UNESCO and UNU.





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New Trends to be Included

- Open
  - Open Software
  - Open Courses
  - (Open) Wikipedia
- National / International

Globalization

- Possible through Science and Technology
- Drinking Water, Energy, Epidemics, Climate Change
- WEHAB from WSSD

Human Needs

- Think of:
  - Ethics
  - Laws and Regulations
  - Prioritization of Issues, Choice of Technology, Local Relevance, Obsoleteness
  - Economic Justification

Bridge Inequities

- More inclusive view of Science and Tech
- Connect Science to MDGs
- Science for Policy and Policy for Science
- Policy major deteminant in Tackling Poverty not Technology

United Nations University

Empowering People/Countries

- Access to Knowledge
- Ability to use / Employ their Knowledge
- Evaluate Current Practice
- Capacity Building for S&T
- Multidisciplinary? Multisectoral?

WORKSHOP SESSION 2
TRADE AND TECHNOLOGY TRANSFER

146-155

Gary SAMPSON, UNU, IAS Chair of International Economic Governance; former Director, Trade & Environment Division, World Trade Organization

TRADE AND TECHNOLOGY TRANSFER

156-168

Decio RIPANDELLI, Director, Administration and External Relations, International Center for Genetic Engineering and Biotechnology (ICGEB)

INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER IN BIOTECHNOLOGY: THE EXPERIENCE OF ICGEB

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WORKSHOP 2 REPORT

RAPPORTEURS:

Claudia ten Have, Ademola Braimoh and Rebecca Carter

CHAIR:

Ana Maria CETTO, Deputy Director-General and Head, Department of Technical Cooperation, International Atomic Energy Agency

Gary SAMPSON

UNU-IAS Chair of International Economic Governance; former Director, Trade & Environment Division, World Trade Organization

Gary Sampson previously held the joint positions of Senior Fellow in Economic Policy with the Reserve Bank of Australia and Professorial Fellow at the Centre of Policy Studies, Monash University. He was then was appointed Director at the General Agreement on Tariffs and Trade, and in 1995 became a Director at the WTO; he directed a number of divisions in both of those organizations. He presently is Professor of International Economic Governance at UNU Institute of Advance Studies (Japan), a Professor at the Centre for Business and Public Policy at the Melbourne Business School (Australia), and teaches on a regular basis at London School of Economics (UK). He has published extensively in both the academic and popular press.

TRADE AND TECHNOLOGY TRANSFER

ABSTRACT

The development of technology and its potential contribution to economic growth and development is a central feature of **globalisation**. In conventional terms, it is well known that **trade** in goods can result in the **transfer of technology**. Ideas and knowledge are an increasingly important part of trade. The rules of the GATT applied to trade in goods and had important implications for the transfer of technology. However, with the greatly expanded coverage of the rules of the WTO to address trade in services, intellectual property rights and technical standards, the potential importance for trade rules to influence technology transfer has increased greatly. This presents **challenges and opportunities**. To benefit from the opportunities, governments should examine the relationship between trade, technology transfer and the treaties of the WTO to determine if new instruments are required to better ensure the free flow of technology around the world.

INTRODUCTION

The development of technology and its potential contribution to economic growth and development is a central feature of globalisation. This is particularly true for the international transfer of technology, or the shifting of ideas and knowledge across borders, and its effective diffusion into recipient economies.

In conventional terms, it is well known that trade in goods can result in the transfer of technology. Ideas and knowledge are an increasingly important part of trade. Most of the value of new medicines and other high technology products lies in the amount of invention, innovation, research, design and testing involved.

Similarly, trade in goods destined for the telecommunications sector, industrial chemicals, fertilizers, and information technology can directly improve production processes. Many products that used to be traded as low-technology goods or commodities now contain a higher proportion of invention and design in their value—for example brand name clothing or new varieties of plants. Technology can also be transferred through trade in counterfeit goods with copied trademarks.

There are other means of transferring technology that have not normally been considered to be trade in the sense of goods crossing borders. Trade in services, such as computer programming services, financial services and consulting, can result in a transfer of technology without the physical movement of goods. There is also the transfer of technology associated with the movement of skilled workers. Some technologies cannot be transferred without the knowledge of engineers and technicians who install turn-key operations. Skilled personnel move internationally between divisions of transnational corporations and foreign direct investment frequently requires the accompaniment of skilled technicians.

Similarly, technology can be transferred via temporary employment of managerial and technical personnel, the movement of students, scientists, and staff to universities, laboratories, and for study, teaching and researching. Returning expatriate students and professionals can transfer technology to local scientific, managerial and business activities.

Technology is also transferred at arms length through franchising and licensing to produce and distribute goods and services. Patents, trade secrets, copyrights, and trademarks are all means to transfer technology.

EXPANDING THE DEFINITION OF TRADE

An extraordinary development of the past decade is the extent to which international transactions that would not normally be considered the object of trade policy are central to the formulation of trade policy. Indeed, all of the above means of transferring technology, are now on the trade agenda.

What has greatly changed the situation is the entry into force of the World Trade Organization (WTO) and the agreements it administers. The reach of the WTO has been extended significantly in terms of its predecessor the GATT, with important implications for the relationship between what is now considered to trade policy and the transfer of technology.

WTO activities now reach deep into domestic regulatory systems of an increasing number of countries and relate to the domestic regulation of financial services, scientific evidence of the effect of hormone treated beef on human health and the international sale of telecommunication services. The Trade Related Intellectual Property Rights Agreement obliges WTO Members to provide for the patenting of life forms and it is seen by some to present a major obstacle to the access of the poor to technologically advanced medicines at affordable prices. Recent WTO disputes have also addressed trade in genetically modified organisms, raised questions about the role of science in the management of risks associated with public health, and dealt with the conservation of endangered species. It is argued that WTO rules frustrate the objectives of other multilateral agreements dealing with matters as diverse as the trans-boundary movements of genetically modified organisms and the rewarding of indigenous people for pharmaceutical products derived from local genetic resources.

The end result of the greatly expanded role of he WTO in world affairs is that the link between trade and the transfer of technology is now explicitly, or implicitly, inextricably linked to a number of WTO Agreements.

This is true of the Technical Barriers to Trade (TBT) Agreement which applies to national standards that specify the mandatory technological requirements of traded goods. These standards determine whether the goods may be imported or not. The TBT Agreement has as its objective the avoidance of standards being applied as a disguised protectionist measures. This could result in the refusal to import sophisticated radiological equipment or advanced internal combustion engines that did not meet domestic standards. Similarly, the Sanitary and Phytosanitary (SPS) Agreement disciplines the use of standards for human, animal and plant safety as disguised barriers to trade. Questions in this respect relate to whether the cross border movement of living genetically modified organisms (GMOs) are harmful to the environment, and whether food products derived from GMOs ar harmful to human health.

Perhaps the most relevant WTO agreements for present purposes are, however, the Trade Related Intellectual Property Rights (TRIPs) Agreement, and the General Agreement on Trade in Services (GATS). These will be discussed below along with their impact on technology transfer.

TRADE IN SERVICES AND TECHNOLOGY TRANSFER

The **General Agreement on Trade in Services** of the WTO emerged from the 1986-94 Uruguay Round. It establishes the rights and obligations that WTO Member countries must respect when trading services as well as the rules that WTO member countries pursue in the liberalization of trade in services. The international movement of services has a vast potential for the transfer of technology and the GATS is particularly relevant in this respect. An important question in determining the importance of GATS for technology transfer is what are the types of services activities the agreement applies to.

The GATT does not define "trade" in goods. Perhaps it is obvious as international trade takes place when merchandise crosses the border. In the case of services, the counterpart of a cross border definition would be, for example, postal services, voice-telephony and telefax services, the provision of which entails a cross-border movement in one form or another. Such a definition would exclude many services where international transactions take place, where technology could be efficiently transferred, but where no services cross the border.

It was thought by trade negotiators in the Uruguay Round that if the definition of trade was based on the manner in which services were supplied internationally, rather than whether the service itself moved internationally, more areas of potential interest to both developed and developing countries would be covered by its rules.

Indeed, Article IV of the GATS refers to technology transfer and its importance for developing countries: "The increasing participation of developing country Members in world trade shall be facilitated through ... the strengthening of their domestic services capacity and its efficiency and competitiveness, *inter alia* through access to technology on a commercial basis ...". Interestingly, the access to technology is to be on a commercial basis.

After much negotiation, trade in services was defined as the supply of a service through any one of the following four *modes of supply*: cross-border movement of the service; consumption abroad of the service; commercial presence in the consuming country of the service supplier; and, presence of natural persons in the importing country to supply the service.

The adoption modes of *supply* as setting the boundaries to the coverage of services transactions has shaped the principles and rules embodied in the GATS, as well as the specific commitments that WTO Members have undertaken. Accordingly, it has had very considerable implications for the manner in which this trade agreement facilitates – or not – the transfer of technology. All modes of supply are direct relevance to the link between trade (as defined in the GATS) and the transfer of technology.

First, the service itself may cross the border from the territory of one Member to that of another (a telephone call from a person located in the territory to a person located in that of another Member). This mode of supply corresponds with the normal form of trade in goods. It is in many ways the most straightforward form of trade in services, because it resembles the familiar subject-matter of the GATT, not least in maintaining a clear geographical separation between seller and buyer.

Second, the service consumer of one Member may move across a border to consume a service supplied by another Member in its own territory (a medical patient temporarily moving to receive technologically advanced medical treatment in another country).

This involves the consumer travelling to the supplying country, perhaps to attend an educational establishment. Another example of consumption abroad would be the repair of a ship or aircraft outside its home country because of more technically advanced facilities than domestically available. Like cross-border supply, this is a straightforward form of trade which raises relatively few problems, since it does not require the service supplier to be admitted to the consuming country or the cross border movement of capital.

Third, a large proportion of service transactions require that the provider and the consumer be in the same place. In such instances there is a need for the presence of a service supplier of one Member through a form of commercial establishment in the territory of the consumer of another Member (a commercial presence to sell retail portfolio management services in the importing country). Examples would be the establishment of branch offices or agencies to deliver services such as banking, legal advice or communications. It could be the commercial establishment of an advanced engineering firm to sell its services in the importing country.

This mode of supply raises the most difficult issues for host governments. The fact that services are, by their nature, perishable and are supplied and consumed at the time of fabrication (e.g. many forms of financial and professional services) requires not the cross-border movement of the service, but the physical presence in the importing country of the service supplier or the physical presence in the exporting country of the service consumer.

Thus, this mode normally requires the admission of foreign nationals and the inflow of foreign capital and offers considerable opportunities for the transfer of technology, particularly if licensing, trademark protection, and other tools to promote the transfer of technology are in place.

The fourth mode of delivery is the movement of natural persons providing services as independent individuals. For example, a surgeon may take his or her technical skills to work in a hospital where a commercial presence has been established, or may be temporarily visiting another country to perform a specialised operation. An Annex to the GATS makes it clear, however, that the agreement has nothing to do with individuals looking for employment in another country, or with citizenship, residence or employment requirements.

While this form of trade may raise difficulties in terms of the need to apply measures to regulate the entry of natural persons (e.g. visas), the situation may change in a number of services activities – particularly in labour intensive services - as a result of technological developments (e.g. services sold on the Internet, computer aided design services). Technological developments may make working abroad less necessary or attractive.

INTELLECTUAL PROPERTY RIGHTS, TRADE AND TECHNOLOGY TRANSFER

Intellectual property rights are the rights given to persons over the creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time.

The Trade-related Intellectual Property (TRIPs) Agreement of the WTO also emerged from the Uruguay Round and establishes the minimum standards for intellectual property protection enforceable in the WTO. It attempts to strike a balance between the long term social objective of providing incentives for future inventions and creation, and the short term objective of allowing people to use existing inventions and creations.

The extent of protection and enforcement of these rights varied widely around the world; as intellectual property became more important in trade, these differences became a source of tension in international economic relations. Internationally-agreed trade rules for intellectual property rights were seen as a way to introduce more order and predictability, and for disputes to be settled more systematically.

One of the fundamental characteristics of the TRIPS Agreement is that it makes protection of intellectual property rights an integral part of the multilateral trading system, as embodied in the WTO. It is often described as one of the three "pillars" of the WTO, the other two being trade in goods (the traditional domain of the GATT) and trade in services.

In respect of each of the main areas of intellectual property covered by the TRIPS Agreement, the Agreement sets out the minimum standards of protection to be provided by each

Member. For the purposes of the TRIPS Agreement, the term "intellectual property" refers to all categories of intellectual property. This includes copyright and related rights, trademarks, geographical indications, industrial designs, patents, layout-designs of integrated circuits and protection of undisclosed information and is therefore of particular relevance for technology transfer. It is unlikely that technology will freely flow to a country that does not have the necessary regulations in place to register and enforce intellectual property rights.

Each of the main elements of protection is defined, namely the subject-matter to be protected, the rights to be conferred and permissible exceptions to those rights, and the minimum duration of protection. The Agreement sets these standards by requiring, first, that the substantive obligations of the main conventions of the World Intellectual Property Organization (WIPO), the Paris Convention and the Berne Convention on moral rights, all the main substantive provisions of these conventions are incorporated by reference and thus become obligations under the TRIPS Agreement between WTO Member countries.

The conventional argument in favour of IPR protection is couched in terms of the need to encourage and reward creative work. Thus, intellectual property rights are designed to provide protection for the results of investment in the development of new technology, thus giving the incentive and means to finance research and development activities. Also, the protection of distinctive signs and other IPRs aims to stimulate and ensure fair competition among producers. As far as consumers are concerned, the protection of distinctive signs also offers protection, enabling consumers to make informed choices between various goods and services. An effective intellectual property regime should also facilitate the transfer of technology in the form of foreign direct investment, joint ventures and licensing.

The argument against the protection of intellectual property rights is based on the thesis that they are monopoly rights, at odds with the whole concept of free trade, and can be used in such a way as to exploit consumers and work against the public interest in general. The counter to this argument is that intellectual property protection provides exclusive, not monopoly, rights for a limited amount of time. Exclusive rights are necessary to fuel the engine of innovation -- which is risky and expensive. Innovation in turn lowers costs, increases quality, and provides new choices to consumers -- in short, it fosters trade.

Developing countries, in particular, see technology transfer as part of the bargain in which they have agreed to protect intellectual property rights. Major developed countries insisted on its inclusion in the total package of the WTO agreements on the grounds that it would increase technology transfer to developing countries. Many developing countries consider the agreement to be unbalanced in this regard and that it is fundamentally unbalanced against their interests. While it is difficult to measure, there is little hard evidence that the TRIPs Agreement has led to a major increase in the transfer of technology to developing countries.

Irrespective of the above arguments for and against the protection of intellectual property rights, most WTO members agree that developing countries have an important interest in providing intellectual property protection, as a way of encouraging more investment, research and innovation from which they should benefit. As they themselves increasingly innovate, they also have an interest in strong intellectual property protection. The experiences of Hong Kong, India, and Korea, for example, demonstrate this.

Some examples: -- Patents encourage discovery and invention of new products or processes by providing exclusive rights, for a limited period, to those who disclose the results of their inventions and thereby help to disseminate and advance the knowledge in both the original field of discovery and other fields. Copyrights encourage the creation of literary works, computer programs, and artistic works, as well as to performers, producers of sound recordings, and for broadcasters as well. These are obviously not interests unique to developed countries. Trademark protection helps to ensure consumers that products or services designated as having originated from a particular source actually come from that source. In that way, consumers can be certain they are getting the products and services they want.

Thus, in formal terms, Article 7 of TRIPs states that technology transfer is a basic objective of TRIPS: "The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

However, Article 40 of the TRIPS Agreement recognizes that some licensing practices or conditions pertaining to intellectual property rights which restrain competition may have adverse effects on trade and may impede the transfer and dissemination of technology (paragraph 2). Member countries may adopt, consistently with other provisions of the Agreement, appropriate measures to prevent or control practices in the licensing of intellectual property rights which are abusive and anti-competitive (paragraph 2).

The TRIPS Agreement does, however, have the requirement that developed countries' governments provide incentives for their companies to transfer technology to least-developed countries (Article 66.2). But it requires only developed countries to provide such incentives, and only on behalf of the least developed countries.

NO OBLIGATIONS OR RIGHTS ARE CREATED FOR THE DEVELOPING AND TRANSITION COUNTRIES.

There is little doubt from discussions in the WTO context that intellectual property rights can stimulate innovation, and that the TRIPs Agreement can have an impact on technology transfer. Licensing technology subject to IPRs allows the transfer of certain know-how, skills and application technologies. Developing countries have noted in the WTO the need to encourage co-operation for establishing appropriate norms and practices that lower transaction costs of intellectual property and dissemination of technology. They have also identified the lack of will by many countries to engage in effective transfer programmes among the major problems that limit technology transfer.

STATE OF PLAY AND CONCLUSION

The Doha Ministerial Declaration has, for the first time in the history of the multilateral trading system, introduced a binding mandate for WTO Members to examine the relationship between trade and technology transfer. To this end, ministers established a Working Group on Trade and Transfer of Technology, open to all Members, to operate within the permanent structure of the WTO.

What is being sought by the developing countries is the full implementation of technology transfer clauses in all WTO Agreements. They are seeking to investigate all provisions of the WTO Agreements related to the transfer of technology and how they are being implemented; have the WTO carry out specific analytical work to better understand the relationship between trade and the transfer of technology; receive more assistance in terms of technical co-operation to better accommodate incoming technology; look for areas of agreement to build a consensus among WTO members as to how to promote the transfer of technology; and inquire into the role of other international and nongovernmental organisations. This broad ranging mandate has been resisted by a number of developed countries.

After negotiation, the Working Group Chair proposed an agenda covering a broad range of issues including: an analysis of the relationship between trade and transfer of technology; work by other intergovernmental organisations and academia; sharing of country experiences; identification of provisions related to transfer of technology in WTO agreements; and any possible recommendations on steps that might be taken within the WTO's mandate to increase flows of technology to developing countries.

In terms of policy directions, it would seem reasonable that given the unfulfilled expectations of developing countries with respect to the TRIPs agreement, serious consideration should be given to adopting a legally binding obligation for developed countries to put in place a mechanism for ensuring the monitoring and full implementation of the obligations of the TRIPs. This should include a binding commitment to promote the transfer of technology. It would also seem appropriate that there is a comprehensive review of the manner in which the entirety of the WTO agreements impact on the transfer of technology, what the implications are from a policy perspective, and if adjustments to current rights and obligations would facilitate a greater transfer of technology between countries.

As far as trade in services are concerned, the Doha Development Agenda is important in terms of prospects for additional technology transfer to developing countries. In these negotiations, governments reaffirmed "that the negotiations shall aim to achieve progressively higher levels of liberalization with no a priori exclusion of any service sector or mode of supply and shall give special attention to sectors and modes of supply of export interest to developing countries. We note the interest of developing countries, as well as other Members, in Mode 4."

The negotiations are being conducted on a request-offer basis, whereby a WTO member requests better access to a particular services sector in another WTO member's economy. This is followed by an offer to grant all, some or none of the additional access requested. What is of critical importance for developing countries is to secure commitments on the temporary movement of skilled workers, discussed as Mode 4 in the section above. Offers to liberalise the temporary entry of skilled workers from developing countries is a means to earn export revenues, encourage the development of skilled based industries, and provide additional learning for developing country services professionals in overseas markets.

Decio RIPANDELLI

Director, Administration and External Relations,
International Center for Genetic Engineering and Biotechnology (ICGEB)

After working in private industry, Decio Ripandelli joined the UN system in 1984 and worked on technical assistance projects in Tanzania, Niger, and the Philippines. In 1989, he entered the Italian Ministry for Foreign Affairs, where he worked on programmes financed by the Government of Italy through UN specialized agencies. He joined ICGEB in 1991. In his current role, he supervises the management of ICGEB and of its two components (Trieste and New Delhi) and also directs the Institutional Services implemented by the Centre. He holds a degree in Natural Sciences and Experimental Geology from the Pierre and Marie Curie University (France).

INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER IN BIOTECHNOLOGY: THE EXPERIENCE OF ICGEB

Some of the major factors that have persistently hindered industrial sector development and economic growth in many developing countries include the critical lack of basic research infrastructure, the lack of adequate economic resources as well as skilled local manpower to conduct the requisite basic and applied scientific research. As a consequence of the current trends in globalization coupled with the breath-taking pace of scientific and technological innovation and advancement in many industrialized nations, most developing countries find it increasingly difficult to cope with the burden of the financial requirements necessary to build local technical and scientific capacity. Any meaningful measures by any institution, organization or government to abate this situation would necessarily prioritize the transfer of technologies from industrialized countries for adoption and execution in the poor countries in order to circumvent the need for capital investment spending, necessary for research and development in the latter.

In recognition of this pressing necessity and also in pursuit of pertinent aspects of its mandate, the International Centre for Genetic Engineering and Biotechnology (ICGEB) is intensively involved in all the aspects of technology transfer as an inevitable tool for skills development and capacity building necessary for stimulating industrial sector productivity, job creation, revenue generation, poverty alleviation and economic growth in developing countries. Particular attention at the ICGEB has been focused to the transfer of technologies and production procedures for the manufacture of generic pharmaceuticals, for the improvement of healthcare systems, owing to the intimate relationship between the state of good health of a population, the industrial sector productivity and the overall economic growth in the nation. In fact, strengthening the capacity for the indigenous production of essential generic pharmaceuticals helps to improve the population's access to these drugs at affordable prices.

Furthermore, there is a general recognition that many developing countries are now becoming potential generators of innovative technologies, although they sometime lack the ability to protect their innovative products or processes: this new paradigm, coupled with the challenges facing the developing economies, which transcend the mere lack of technologies or the difficulties for their acquisition, but refer to the inherent difficulties related to the adoption of Intellectual Property Right (IPR) regimes, as foreseen by the WTO and its Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, is being also addressed by the ICGEB, through its own approach to IP protection as well as through new initiatives that should involve a number of institutional and international partners.


INTELLECTUAL PROPERTY
AND
TECHNOLOGY TRANSFER IN
BIOTECHNOLOGY:
THE EXPERIENCE OF ICGEB
Decio Ripandelli - Yokohama, 24 August 2006


Structural and functional genomics and related biotechnologies are keys for the development of healthcare and agricultural innovations over the coming decades.


It is essential for developing countries to possess skills in the basic and applied aspects of recombinant DNA technology and its control.

Each country must endeavour to improve its scientific education and governments should learn to rely in unbiased scientific opinion and not color it politically.

Proper scientific education means

not necessarily the fashionable competitive science but to

learn and apply the scientific method with logic and rigour.

The correct assessment

of the options for development is only possible if there is an

educated scientific category.

ICGEB

ICGEB Signatory Countries (March 2006)

SIGNATORY COUNTRIES (71)

Afghanistan (MS)
Algeria* (MS)
Argentina* (MS)
Armenia §
Bangladesh* (MS)
Bhutan (MS)
Bolivia
Bosnia and Herzegovina § (MS)
Brazil* (MS)
Bulgaria* (MS)
Cameroon §
Chile* (MS)
China* (MS)
Colombia* (MS)
Congo
Costa Rica* (MS)
Côte d'Ivoire (MS)
Croatia* (MS)
Cuba* (MS)
Democratic Republic of the Congo
Dominican Republic §
Ecuador (MS)
Egypt* (MS)
FYR Macedonia* (MS)
Georgia §
Ghana §
Greece*
Hungary* (MS)
India+ (MS)
Indonesia
Iran* (MS)
Iraq (MS)
Italy+ (MS)
Jamaica §
Jordan (MS)
Kenya §
Kuwait* (MS)
Kyrgyzstan § (MS)
Liberia (MS)
Mauritania
Mauritius (MS)
Mexico* (MS)
Morocco* (MS)
Nigeria* (MS)
Pakistan* (MS)
Panama (MS)
Paraguay §
Peru* (MS)
Philippines §
Poland* (MS)
Romania (MS)
Russia* (MS)
Saudi Arabia (MS)
Senegal* (MS)
Serbia and Montenegro* (MS)
Slovakia*(MS)
Slovenia* (MS)
South Africa* § (MS)
Spain
Sri Lanka* (MS)
Sudan* (MS)
Syria* (MS)
Tanzania* (MS)
Thailand
Trinidad and Tobago (MS)
Tunisia* (MS)
Turkey* (MS)
United Arab Emirates § (MS)
Uruguay* (MS)
Venezuela* (MS)
Viet Nam* (MS)

INSTRUMENTS OF ACTION

- RESEARCH PROJECTS
- LONG TERM TRAINING
- SHORT TERM TRAINING
- COLLABORATIVE RESEARCH PROGRAMME
- INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER
- SCIENTIFIC SERVICES
- INSTITUTIONAL SERVICES

SUMMARY OF THE ACTIVITY OF THE ICGEB (1988-2005)

• INTERNATIONAL PUBLICATIONS:	>1,400
• LONG TERM FELLOWSHIPS:	500 awarded; > 1,000 MTRAINEE/YEARS
• SHORT TERM TRAINING:	8,000 persons trained
• RESEARCH GRANTS:	285 awarded (for a total of US$ 15,000,000)
• PATENTS:	40 filed
• TECHNOLOGY TRANSFER AGREEMENTS:	71 signed

Capacity Building?

- C.B. is not defined through the instruments used, but through its goal to enhance the capability of people and institutions to improve their competence and problem-solving capacities (GTZ 1999).
- C.B. refers to investment in people, institutions and practices that will, together, enable countries in the region to achieve their development objectives (World Bank 1997)
- C.B. is the process by which individuals, groups, organizations, institutions and societies increase their abilities to understand and deal with their development needs in a broad context and in a sustainable manner (UNDP 1997).
- C.B. may be defined as the actions needed to create or enhance the capability of a country or an institution (or an individual) to carry out its allotted functions and achieve its objectives (UNDP 1993).

INSTRUMENTS OF ACTION

- RESEARCH PROJECTS
- LONG TERM TRAINING
- SHORT TERM TRAINING
- COLLABORATIVE RESEARCH PROGRAMME
- INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER
- SCIENTIFIC SERVICES
- INSTITUTIONAL SERVICES

INSTRUMENTS OF ACTION

- **INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER**

INSTRUMENTS OF ACTION

- **INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER**

  ⇒ **ICGEB patents**

  ⇒ **proprietary technologies**

  ⇒ **generic products**

Technology Transfer

- flow of scientific knowledge and technical capacity from originator/s to a larger public domain for acquisition and utilization in order to generate goods and services

- process through which scientific invention, innovation or discovery developed in a given sector is made available to industry for possible commercial exploitation

❑ Benefits of Technology Transfers

- technology acquisition without time and capital intensive R&D
- increased capacity building and skills development of technology recipients
- increase the availability of generated products, increase market opportunities and improve living conditions
- creation of employment opportunities and increase in industrial sector productivity
- revenue generation and poverty alleviation

❑ Technology Transfer in Developing Countries

- essential/inevitable tool for industrial sector development, productivity and economic growth
- circumvents the burden of R&D financial requirements as well as time constraints for development of local capacity
- addresses the scientific and digital divides between industrialized and developing countries

The ICGEB Vision of Technology Transfer

- embraces both long-term measures aimed at capacity building and skills development as well as short-term ones for the immediate production of goods and services

Short-term Measures for Technology Transfer at the ICGEB

- development of procedures for the production of recombinant generic pharmaceuticals
- transfers to desiring institutions in ICGEB Member States and pharmaceutical industries (in three stages)
  - scientists from acquiring institutions are trained at the facilities of the ICGEB
  - trainees reproduce the production process under close supervision by ICGEB staff
  - trainees repeat production at the facility in home country
- successful transfer upon success in stage 3
- supportive of relevant aspects of Doha Declaration of 2001

DECLARATION ON THE TRIPS AGREEMENT AND PUBLIC HEALTH

Adopted on 14 November 2001

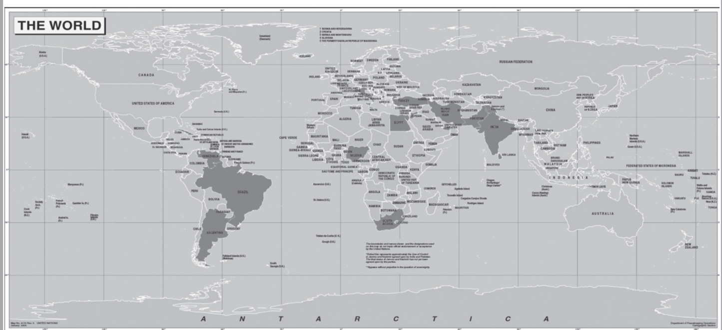
- We reaffirm the commitment of developed-country Members to provide incentives to their enterprises and institutions to promote and encourage technology transfer to least-developed country Members pursuant to Article 66.2.

- We agree that the TRIPS Agreement does not and should not prevent Members from taking measures to protect public health. Accordingly, while reiterating our commitment to the TRIPS Agreement, we affirm that the Agreement can and should be interpreted and implemented in a manner supportive of WTO Members' right to protect public health and, in particular, to promote access to medicines for all.

Recombinant Pharmaceuticals, Vaccines and Diagnostics Developed at the ICGEB

- **ERYTHROPOIETIN - EPO**
- **HUMAN INTERFERON (ALPHA - BETA - GAMMA) - IFN**
- **GRANULOCYTE COLONY STIMULATING FACTOR - GCSF**
- **HCV DIAGNISTIC KIT**
- **HIV DIAGNOSTIC KIT**
- **DENGUE DIAGNOSTIC KIT**
- **HEPATITIS B VACCINE**

72 TECHNOLOGY TRANSFER AGREEMENTS
IN 18 COUNTRIES
HAVE GENERATED OVER 3 MILLION EURO (2003-2005)



❑ ICGEB-transferred technology is cost effective

Erythropoietin (EPO)

packaged in 4000 IU/vial/dose

global market for EPO is about USD 2.5 bn

public price in pharmacy is USD 70.0/dose

Production costs for 4000 IU

active ingredient USD	1.3
packaging	1.5
Total	USD 2.8

total working days starting from cell culture to QC are about 21

Interferon alpha 2A (IFN)

packaging as 3MIU (11.1 μg product/0.5mL)

global market for the product is USD 80 million

public price in pharmacy (3MIU) is USD 25.0/vial

ICGEB technology yields approx. 80mg pure product/litre of culture

Production costs for 3MIU

active ingredients	USD 0.3
packaging	USD 1.5
Total	USD 1.8

Total of ten working days

Granulocyte colony stimulating factor (G-CSF)

packaging as 300 μg/ml in 0.5 ml prefilled syringes

global market for the product is USD 1.5 billion

public price in pharmacy is USD 250.0/0.5 ml syringe

yields at ICGEB are above 100mg pure product/litre of culture

Production costs for 300 μg

active ingredients	USD 0.3
packaging	USD 1.5
Total	USD 1.8

Total of ten working days

❑ Commerciability and Potential Sales

- the technology and procedures for the large-scale production of EPO, IFN and G-CSF are optimized and standardized to the requirements and specifications of both the EU Pharmacopoeia and those of the US FDA.
- their properties will also satisfy the regulatory requirements of any acquiring country
- advantage of greater affordability due to lower production costs
- technology transfer at the ICGEB costs a token fee which represents a nominal contribution to R&D expenditure
- ICGEB technologies stimulate industrial sector productivity and economic growth, job creation and generates revenue

❑ Production Costs/Economic Returns

❖ Erythropoietin:

- total investment to set up plant (equipment, instruments and all necessary reagents/chemicals) amounts to just over USD 1,000,000
- minimum potential sales would amount to at least USD 5,500,000 in the first year of production

❖ Interferon and G-CSF:

- total investment to set up plant (equipment, instruments and all necessary reagents/chemicals) amounts to USD 1,200,000
- minimum potential sales would amount to USD 2,800,000. in the first year of activity for interferon
- for G-CSF the minimum potential sales in the first year of production is approximately USD 9,600,000

ICGEB AND IPRs

Objectives of ICGEB *(as per its Statutes)…*

- " […] to assist developing countries in strengthening their scientific and technological capabilities in the field of genetic engineering and biotechnology" *[art.2(a),(d),(c)];*
- "[…] to support in particular research development and application for the benefit of developing countries and maintain close contacts with industry" [art. 3(a),(h),(j)];

… the MEANS for the practical achievement are twofold *[art. 14(1),(5)]:*

- publication of all results of its research activities is MANDATORY "provided such publication does not contravene the general policy of IPR as adopted by the Board";
- "patent and other rights and any financial or other benefits associated herewith shall be used".

The effective utilisation of rights is secured through:

- the OWNERSHIP of ICGEB in all rights relating to any work produced or developed by the Centre *[art.14.(2)];*
- ICGEB rules regulating access to IPR is in "accordance to applicable international conventions" *[art. 14(4)].*

===> POLICY GUIDELINES ON PATENTS, LICENSING, COPYRIGHTS AND OTHER RIGHTS TO IP OF THE ICGEB
(adopted by the ICGEB Board of Governors, November 2000)

LIFE OF AN ICGEB PATENT APPLICATION

NOTIFICATION OF THE APPLICATION TO ICGEB MEMBER STATES

- FOLLOWING THE FILING OF A PATENT APPLICATION, ICGEB SHALL INFORM ITS MEMBER STATES;
- WITHIN 4 MONTHS (AND NOT LATER THAN 8 MONTHS FROM THE PRIORITY DATE), MEMBER STATES CAN INDICATE THEIR SPECIFIC INTEREST IN THE INVENTION;
- ICGEB WILL EXTEND THE PATENT ALSO IN THE(SE) MEMBER STATE(S) THAT SO REQUIRE;
- FILING AND MAINTENANCE COSTS IN THAT SPECIFIC MEMBER STATE WILL BE BORNE BY THE RELEVANT GOVERNMENT;
- THE CENTRE IS ALSO <u>FREE</u> TO FILE SUBSEQUENT PATENT APPLICATIONS IN OTHER STATES, INFORMING THE RESPECTIVE MEMBER STATE ACCORDINGLY.

LIFE OF AN ICGEB PATENT APPLICATION

OWNERSHIP OF DATA

- ICGEB STAFF MEMBERS (AND VISITING FELLOWS) HAVE TO VEST IN THE CENTRE ALL RIGHTS, INCLUDING TITLE, COPYRIGHT AND PATENT RIGHTS, IN ANY WORK PERFORMED AS PART OF THEIR OFFICIAL DUTIES;
- RESULTS EMANATING FROM THE RESEARCH IMPLEMENTED IN THE FRAMEWORK OF THE COLLABORATIVE RESEARCH PROGRAMME BELONG TO THE AFFILIATED CENTRE AND TO THE SCIENTISTS WHICH HAVE CARRIED OUT THE RESEARCH;
- IN CASE OF INVENTIONS PROTECTED AT THE EXPENSES OF A MEMBER STATE, THE PATENT WILL BE CO-OWNED BY THE ICGEB AND BY THE RESPECTIVE MEMBER STATE.

LIFE (AND DEATH) OF AN ICGEB PATENT APPLICATION

COMMERCIAL DEVELOPMENT

IN CASE OF INVENTIONS OF POTENTIAL COMMERCIAL VALUE:

- THE DIRECTOR-GENERAL WILL NEGOTIATE NON-EXCLUSIVE OR EXCLUSIVE LICENSE AGREEMENTS WITH INDUSTRIAL PARTNERS;
- SUCH LICENSE AGREEMENT WILL CONTAIN A <u>DOWN PAYMENT</u>, PAYABLE IN SEVERAL INSTALMENTS (e.g. 40%-40%-20%) AND <u>ROYALTIES</u> AS A PERCENTAGE (e.g. 2-4%) OF THE NET SALES OF PRODUCTS SOLD);

ABANDONING A PATENT

AN ICGEB PATENT APPLICATION IS ABANDONED:

- SHOULD THE PATENT OR THE PATENT APPLICATION PROVE NOT TO HAVE ANY COMMERCIAL VALUE;
- SHOULD NO SUITABLE INDUSTRIAL PARTNER BE IDENTIFIED WITHIN 30 MONTHS FROM THE PRIORITY DATE.

BENEFITS FROM AN ICGEB PATENT: A CASE STUDY

THE PRODUCT: USING AN INSECT VIRUS AS A CARRIER FOR THE PRESENTATION OF MULTIPLE EPITOPES SHOWING HIGH ANTIGENIC PROPERTIES (MOLECULAR PRESENTING SYSTEM).

PROCEDURAL ITER

08/08/94 FIRST FILING IN AUSTRIA (**PRIORITY DATE**)

04/08/95 INTERNATIONAL EXTENSION VIA PCT

01/03/96 INTERNATIONAL PRELIMINARY EXAMINATION (**IPE**)

08/02/97 ENTERING THE REGIONAL (EUROPE) AND NATIONAL (USA) PHASES

28/08/98 LICENSING OF THE PRODUCT TO A US PHARMACEUTICAL COMPANY

WORKSHOP 2 REPORT: TRADE AND TECHNOLOGY TRANSFER WORKING GROUP SESSION

Specific trends

- Increasing role of select developing countries in the innovation and production of advanced technologies (Cuba, India, South Africa, Brazil….)
- Open source, open access technologies in ICT and possible lessons learnt
- Upsurge in international trade in services and the profound implications on technology transfer

Challenges and opportunities

- Ethical issues in relation to IPR protection for sensitive products (e.g. life saving drugs)
- Shift in the process of North - South dialogue (e.g. Doha Development Agenda)
- Suspension of DDA: opportunity for re-evaluation and development of new proposals
- Discrimination between real scientific objections and protectionism

Role of UNU and UNESCO

- Need for neutral space for policy dialogue and debate on IPR and Trade
- Continued capacity development of science and technical specialists in developing countries
- Providing a forum for dialogue between opponents and proponents of globalisation

Specific Proposals for the future

- Re-examine the relationship between and rules of Trade and Technology transfer: to promote coherence and coordination between these and the institutions that govern them
- Developing countries have valid, unfulfilled expectations of TRIPS: fully implement TRIPS preamble and develop legally binding obligations and monitoring mechanisms
- Facilitate movement of technical staff from developing countries for short-term skills development for effective uptake of new technologies

WORKSHOP SESSION 3 SOCIETY AND POLICY-MAKING

Issa KALANTARI

former Iranian Minister of Agriculture
President of the Iran's Farmer's House

Issa Kalantari served as Iran's Minister of Agriculture from 1988 to 2000, and then as Advisor to the President of Iran from 2000 to 2005. He joined the Ministry of Agriculture in 1982, serving successively as Head of the Agricultural Extension Organization; Head of the Plant and Seed Improvement Institute; and Deputy Minister of Agriculture for Research, Education, and Extension. From 1985 to 1988, he was Managing Director of Moghan Agro-Industrial Complex. Dr. Kalantari has also served as President of the United Nations World Food Council (1991–1996) and President of Iran's Farmer's House. He holds a Ph.D. degree in Crop Physiology from Iowa State University (USA).

GLOBALIZATION, SOCIETY, POLICY-MAKING: A GLOBAL PERSPECTIVE

Nowadays the world is gradually shrinking, followed by intimate multilateral relationships. This we assume that might be indebted to progress in technology and telecommunications. But to be outspoken and honest, technology, economy and trade are not the sole causal agents. Therefore, we must seek for the origin of such issues in the exchange of ideas and doctrines which are bearing such a speedy advancement that everybody is doing their utmost to seize the priority.

In the third-world countries this topic is scanned under two distinct terms: **globalization** and **global making**.

The first concept is the outcome of science and technology advancement, and it is to the benefit of all the states to join such a movement. The latter which has a root in ideology in fact is a west-orientated perception whose main objective is fruiting the benefits of the west in particular USA, formerly hoaxed as clonialisation. In my opinion that is the duty of the countries in the South to stage campaign against the imposition of such socio-cultural issues originated from western ideology.

My statement is a reflection of the thoughts of a statesperson and a technocrat following 25 years of experience. Everybody is in concord with this fact that globe management is a matter of question from different points of view. We are witnessing the result of which in diverse dimensions such as: economy, Politics, bio-environment and human.

The resources of this planet the earth is continuous depleting. Fossil fuels, mines and minerals art being exploited drastically in such a trend that reserves diminishing is certified daily. Forests are on the brink of extinction and water resources are deteriorating and liable to salinity. Genetic resources comprising of plants and animals, fertile soils exposed to erosion, pollutions of different kinds and global heat increasing at a drastic speed.

From social points of view, the comfortably-offs grow more comfortable and the badly-offs, became worse. Approximately one thousand million of the world population is suffering from hunger and over two thousand million are deprived of having an access to drinkable water.

Still there exists people who have not touched the sense of freedom. Dictatorial or pseudo dictatorial governments within the pretext of different ideologies such as capitalism, communism., socialism or ever religious fanaticism have dispossessed them front freedom-this very blessing of God the Almighty. A good number of them arc being exploited under modem terms.

It is sad to say that globalization hardly individual communities have partaken, and mostly the states people have been the architects of such premises. Therefore less attention has been paid to the problem the ordinary citizens are entangled with and they deal more with commercial and financial issues. Multitude number of social, cultural and human problems arc ruled out as a consequence.

Those who are living in countries with developed civil foundations and enjoy the existence of trades, political and specialized organizations, are fully aware of pros and cons of globalization.

As a result they welcome globalization with cage provided the dilemmas and ambiguities hereof axe lofted. But in countries where civil communities are less developed, or dictatorial governments are the rulers, or states have seized the power within the framework of restricted elections -since in such governments the power of the authorities is limited-they are not in concord globalization even without any problem or ambiguity. In these countries people are not entitled to express their views, and they inevitably follow the decisions taken by their rulers. As a consequence resistance become more prevalent.

Counter-effects of globalization and structural components of communities such as trades, politics, religions and ethnics must be studied thoroughly in depth. If we consider some of the now-existing problems resulted from globalization which they art mainly rooted in abnegating human spirituality and merely focusing on trade and economic issues, then we will gain success in converting the viewpoints of the majority from opposition to concord and harmony. In order to materialize such process, the imposition of some modifications in the concept of globalization alongside with paying respect to the comments of the critics are badly needed.

In the process of globalization, favour and welfare of each individual on the surface of this globe is to be emphasized, and prioritize them to the benefits of a scanty number of powerful countries who are chiefly responsible for safeguarding the international organizations budgets.

Globalization must be speculated in the concept of advancement and elevation of man while employing total facilities and resources on the surface of this planet the earth. To successfully implement the decisions adopted, careful attention must be directed towards countries' internal structures alongside with the counter-effects of social infrastructures with globalization. As a consequence the world statesmen do not entangle themselves with public beliefs and eventually supreme objectives of globalization shall be overshadowed by marginal issues.

Fortunately the dictatorial period of those dogmatic and a priori rulers is waning in the light of intelligence era and information explosion which have led to the citation of figurative communities and civil groups who are gallant enough to ask for their abnegated rights which once were forlorn.

Therefore, different communities next to their ever-increasing awareness, cause the spread of democracy and welcoming the views of the majority. As a consequence there is no room to worry about the repulsive effects of some senile beliefs and traditions and even dictators for the development of globalization process. But a sheer fact that cannot be ignored is that we shall be witnessing merging of globalization and westernization to with the utter dominance of their media over the whole process.

Unilateral information dissemination shall undoubtedly lead to the intelligence exploitation, which in this respect we should experience concern that the communities entity and culture shall gradually be overlooked in the destitute and impoverished countries who constitute a major portion of the world civilization.

In globalization fear for the storage and application of genocide weaponry by the powerful states and their agents, does exist, lest this armament may be employed to suppress other humans. To me those responsible for globalization should be very much worried about this issue.

If we envisage that the objective of globalization is a proper and sustainable utilization of natural resources and economic privileges in different zones in order to improve the existing situation and to upgrade the spirituality of man on the surface of the planet the earth, we must contemplate the following issues in depth and address the communities and their construction components as under:

- The hazards of illiteracy,
- The existing immense class distinction,
- The expansion of poverty and malnutrition.
- The improper hygiene and sanitation,
- The deprival of individual freedom
- The existence of dictatorial and hereditary governance,
- The non-observance of human rights
- The denial of majority's votes,
- The threat of global warming,
- The improper consumption of fresh-water resources,
- The waste in energy usage in particular fossil fuels,
- The devastation for forests and mines,

We must consider this fact that policy-making in countries are over shadowed by politicians alongside with the policies adopted by international organizations. It is sad to say that in the most third world countries politicians are the sole decision-makers towards their own personal benefit due to a community's political and social backwardness and the absence of free and independent elections. In these countries owing to weak and less dynamic supervision of the mass and the absence of independent surveillance over the government's activities, we repeatedly come across widespread dictatorial doctrines and cultures, corruption, bribery and abuse of facilities and budget by the state's dignitaries.

This is my staunch belief that one of the prime responsibilities of international organizations and in particular United Nations Organization is staging campaign against corruption and misuse of financial resources and physical facilities by the authorities of these governments. Nowadays similar to the struggle against terrorism, campaign against abuse of power experiences by the leaders and rulers of different countries should he encouraged. This in fact is one of the pre-requisites of globalization.

Towards the implementation of these issues, although UNO has stepped positive paces alongside with the ratification of the third millennium objectives, stilt they are facing three chief obstacles as under:

- To achieve a common unanimity, a good number of the above-mentioned subjects have been eliminated from the list of the targets.
- To materialize the adopted decisions by international organizations, there does not exist any executive safeguarding.
- To discard unjust and biased policies adopted by international organizations among them UNO worth mentioning, which belong to the impaired policy of the a priori century, a policy which was based upon running with the hare and hunting with the hound.

CONCLUSION AND RECOMMENDATIONS

1) The concept of globalization should be contemplated and revised. Trade and economy should be assigned among the WTO undertakings. The actual location of planet the earth and the spiritual elevations of its residents should be heeded. Scientific and sustainable utilization of the entire facilities and resources alongside with its privileges should be replaced by the current and existing concept.

2) Further care should be oriented towards the salvation of the earth from devastation, Those countries which created serious pollution and threats to this planet through irresponsible and excessive exploitation of the resources should be penalized, compensate and invest more capital and endeavour comparing with the ones who benefited the least.

3) More attention to the counter-effects of the ethnics, religions, and cultures with regard to the concept of globalization is due. Further studies in this respect are badly needed. This shall result in lessening the trend of civil communities rational resistance against globalization and the pertinent modifications. As a consequence, globalization shall expand at a very higher speed.

4) A proposition can be put forward in this way: In order to ease the independence of international organizations and release them from financial restraints and dependence to a number of superpowers, a type of comprehensive world wide taxation being levied on activities such as exploitation of mines and quarries, forest, and industrial products like car manufacturing and the resulting pollutions. Such an income should be allocated to those international organizations with the chief objective of enhancing the administrative calibre on one hand and relieve them from the burden imposed by those countries who are financially seconding them on the other hand.

5) In order to expedite the trend of globalization with its new concept that can be administrated by all the countries throughout the world, the following measures are to be taken:

   - Implementation of necessary modifications in the structure of the UNI and dwindling the authorities of Security Council while further empowering the General Assembly.
   - Replacement of impaired policies of international organization with trust-making sustainable policies,
   - Imposition of force for the utter implementation of the adopted decisions by all the countries worldwide.

Assisting civil foundations and NGOs of different sorts in particular in the third world countries. This shall lead to even further participation of these communities in policy-making and as a result democracy, human rights and sustainable development shall flourish, and finally the era of dictatorship and hereditary non-elected sovereignties shall terminate, and violence and suppression shall pave the way for dialectics and rationality.

Now it is high time we enjoyed a world void of war and bloodshed, poverty and hunger, comprising of communities populated with spiritually elevated citizens, who are against corruption and devastation and are intimate friends of nature and environment — **An Authentic Utopia**.

Katepalli R. SREENIVASAN

Director, Abdus Salam International Centre for Theoretical Physics (ICTP)

Professor K.R. Sreenivasan joined Yale University as Assistant Professor of Engineering and Applied Sciences in 1979 and became a Professor in 1985. He held the Harold W. Cheel Professorship of Mechanical Engineering from 1988, also holding joint appointments in the Departments of Physics, Applied Physics, and Mathematics. He moved to the Institute of Physical Sciences and Technology (IPST) at the University of Maryland as the Distinguished University Professor and Glenn Martin Professor of Engineering and Professor Physics. He was the Director of IPST during 2002-2003. He is the Director of the Abdus Salam International Center for Theoretical Physics, Trieste, Italy. He has served as the Chairman of Mechanical Engineering at Yale (1985-91), as Chair of the Division of Fluid Dynamics of the American Physical Society (APS) in 1991, and as a member of the Publications Oversight Committee of APS. He is a recipient of the Otto Laporte Award of APS and the Ferrari Prize from the Torino Academy of Sciences.

GLOBALIZATION, SOCIETY AND POLICY-MAKING

Since this meeting is being held in the overall context of globalization, let me begin with a few remarks on that subject. I am aware that very little that is new can be said.

Globalization means free trade, free flow of capital and people, and free access to ideas and technology across the world. It is not a new phenomenon. The first great expansion of European capitalism took place in the 16th Century, and the late 19th Century saw a great expansion in world trade and investment. This trend was slowed down by the First World War and the subsequent disenchantment with free trade, but, on hind sight, it appears to have been a temporary let up in the inexorable trend of globalization. The rapid industrialization following the Second World War hastened it; the fall of the Berlin Wall and the collapse of the Soviet Union removed the remaining obstacles. The development of the internet enabled the organization of business on a wider scale with far greater facility and speed than ever before.

What is new in our era is the incredible speed with which the flow of capital and ideas takes place across the world. This has opened up enormous opportunities for creativity and economic growth. Indeed, some countries have been quite successful in adapting to this environment. But the benefits of globalization have not been felt universally, and some countries have lost out. This unevenness is only one reason for the resentment against globalization. Globalization seems to have diminished cultural diversity and disrupted social relationships and local traditions. The resentment arises also because free migration of people leaves in its wake intense problems for both the donor and recipient countries. This is not an anti-immigrant sentiment but rather an anti-immigration view. On balance, intense globalization has been a mixed blessing.

The universal values of science make it, in some sense, a natural ally of globalization. The sense that the world is one unit was, in fact, enhanced through science and its derivatives, such as the establishment of the International Date Line and time zones, the nearly universal adoption of the Gregorian calendar, of international standards for weights, measures, telegraphy, signalling, and so forth. Especially after the Second World War, the adaptation of English as the primary language of science has hastened globalization. Internet, satellites, electronic publication, distance learning, sharing of experimental facilities and data (often necessitated by escalating costs), have all made it more natural to practice science on a global platform. It is quite easy for scientists to communicate adequately, whatever their cultural or ethnic backgrounds.

Following the general pattern of migration, scientists have also migrated from poorer to richer industrialized countries. Of the 2% or so of the world's population that is presently in the process of migrating to a new country – some of it legally, some of it otherwise – the number of scientists is but a miniscule fraction. Yet, their migration has wide impact on education, scientific culture, technological development, and national morale. To emphasize my point, let me recall the following facts:

- The migration of scientists from Europe to the U.S. during and immediately after the Nazi era shifted the center of gravity of science from Europe to the US. The process involved relatively few people, but the impact on science and on university education has been immense for both Europe and the US. The technical superiority that the US acquired during these years continues even now – one might say, because of its sustained policy (with occasional deviations) of embracing immigrant scientists. For example, three of the four US Nobel Prize winners in 1999 were first-generation immigrants.

- Conversely, after the '70s a large number of scientists from developing countries moved, and are still moving, to the US and Europe. This migration is regarded as "brain drain" on the whole, constantly eroding the scientific capacity of the developing world.

- After the '90s, a rapid migration of scientists occurred from the former Soviet Union to Europe and to the US. It is estimated that some 200,000 scientists have moved away, essentially decimating the once-thriving centers of excellence in USSR, causing an estimated annual loss of 50 billion dollars.

It is perhaps appropriate to recall the remark attributed to the 17th century French scientist, Blaise Pascal (1623-1662). He said that France would become an idiot nation if some 300 of its scientists left the country.

Altogether, therefore, the issue of migration of scientists deserves special attention. This is what I shall comment upon, and discuss how it feeds into public policy.

It appears relatively clear that the permanent immigration of scientists has had detrimental effects on donor countries. But the mobility of scientists and their free movement for purposes of building connections and common projects has been extremely beneficial and, in fact, essential. The most spectacular example of the benefits of mobility of scientists is modern China. After the concerted migration of Chinese scientists to the U.S. in the 80's and early 90's, many returned to China and drastically altered the scientific and technical landscape of their country. This kind of mobility makes the concept of "brain drain" less meaningful for countries like China. Regretfully, however, the situation is less sanguine for some other countries, especially in the sub-Saharan Africa. For those countries, the mobility of scientists has made the risk of losing the best and the brightest even more real than before.

Thoughtful people now agree that building scientific capacity in any part of the world is essential. This situation is truer now than before, for two reasons: first, the world is connected more than ever, and, second, our planet is under such pressures where poor decisions may lead to irreversible exhaustion of its resources. Such prospects include climate changes, the depletion of fisheries, minerals and water resources. In the long run, large-scale depletion of scientific capacity in any part of the world is detrimental to all its parts. The prospect of development in a sustainable context will only underline the need to enhance scientific capacity in all parts of the world.

It thus appears natural to conclude as follows: whatever the merits or drawbacks of wholesale transfer of goods and capital, it is not beneficial, as a rule, for wholesale immigration of scientific communities to occur from poor countries to rich ones. It is important, however, to have a free mobility of scientists for short periods of time, crossing national boundaries periodically and developing international communities within which free exchange of ideas is rendered possible.

Thus, the first policy issue that I would highlight is this: how to discourage permanent migration of scientists from poor countries to industrialized nations, while at the same time enable their mobility on short term, so that everyone who is competent is enabled to pursue his best scientific interests? This requires the development of scientific competence within the broad mandate of encouraging diversity. To do justice to both diversity and excellence is demandingly difficult, but it is necessary to attempt it.

The world has witnessed a true revolution in ITC – or information and telecommunication technologies – and it is only natural that we should use ITC more and more effectively to supplement the physical mobility of scientists. But the promise of these technologies has been limited in developing countries by what is known as the "digital divide". For instance, the speed of internet connectivity in Africa (on the average) is a few hundred times slower than in the US (on the average). Thus my second issue: What enlightened policies should the governments pursue in order to make easy access to internet and the knowledge base available to its population?

Even if the speed of the internet in developing countries can be enhanced, there is almost nothing that can supplant personal meetings when it comes to matters of science. What is required is a judicious combination of the mobility of scientists and the use of ITC to hasten the building of scientific capacity all over the world.

The third policy issue is related to intellectual property rights. If intellectual property is potentially a tool for the benefit of large parts of the poor population of the planet, it should be particularly made available to them. For example, the platforms of new biotechnologies, nanotechnologies and genetic engineering could help the alleviation of suffering from deadly diseases. Yet, many of the cures are owned by small groups of people who are in the business of making money for themselves.

More generally, the important policy issue is the enhancement of the connection between science and wealth creation. The precise connection is tortuous and unclear, but it is clear that there exists one. For those countries in which this connection has been clear, the support for science and its practice have generally flourished. Where the connection is tenuous, science has been seen as a luxury and stagnated.

A century ago, perhaps, economic development did not have to consider the finiteness of earth's resources as seriously as now. We have indeed encroaching on the limits of sustainability. While some details of sustainable development are also controversial, the basic tenet is not. Whatever the past, there is no question that poor countries in quest of economic development cannot follow the same technological path that industrialized countries followed during their ascension. Take energy, for example. The path that the industrialized countries followed – which was a function of the history, available resources, ability to harness them, and so forth – was based on the oil-rich world. This cannot be sustained because the resources cannot keep up with the increasing demands.

It is thus clear that developing countries, some of which have the "luxury" of taking a fresh look at the energy crunch, should look for new and alternative approaches. This requires clear awareness of the issues involved, deep understanding of potential technologies and, as a precondition, much research and knowledge of science. I cannot argue in favour of science any stronger than by stating that it is a matter of survival: an increasing number of problems will depend on science for their solutions. This is my major, though general, point. How to increase a sense that one should not trade today's well-being for tomorrow's disasters, not only as it relates to one's own country or neighbourhood but also as it relates to the world as a whole? This seems to be a big policy issue of enormous political dimension. International institutions like UNESCO have to step up to the fore in forging this attitude but they seem to lack both the resources and the willingness.

In summary, globalization is not a transient phenomenon. It is clear that terrorism, extremism, provincialism, protectionism, and so forth, will slow the trend – alas, at great cost and suffering – but it seems that the technology is advancing in the direction that cannot be reversed. It is therefore especially important to protect cultural diversity and heritage, and to protect the environment. This should underlie all bottom lines calculations in business; this should be the emphasis of all policy matters. True globalization will eventually react to environmental disasters, but presumably only after they have occurred and a profit made.

Once upon a time, the overwhelming threat to the world was through the nuclear weapons. That threat has not fully disappeared but the matter of comparable urgency for our time is one of sustainable development. Keeping these matters on the front burner of all policy-making processes is the challenge of our times.

Douglas C. PATTIE

Environmental Affairs Officer
United Nations Convention to Combat Desertification (UNCCD)
Bonn, Germany

Douglas Pattie is responsible for scientific issues related to desertification in arid, semi-arid, and sub-humid lands where policy issues relate to early warning, migration, natural disasters, traditional knowledge, and desertification benchmarks and indicators. From 1993 to 2003, he served as Project Manager at the International Tropical Timber Organization (ITTO, Japan) for sustainable forest industry projects in Malaysia, Indonesia, Brazil, and Congo Basin countries. Dr. Pattie previously served in the US Department of Agriculture, Forest Service, as an analyst in forest planning, and was a US Peace Corps Volunteer in Nepal, where he provided technical assistance for the construction of suspension bridges and drinking water systems. He holds a Ph.D. degree from Colorado State University (USA).

STRATEGIES TO INTEGRATE TRADITIONAL AND MODERN KNOWLEDGE

Taking as a starting point that traditional knowledge is in a continuous process of change, adaptation and innovation, what can be learned from traditional knowledge? What makes traditional knowledge successful? And how can it be linked and integrated with modern knowledge?

Why do we care about this? First, because the several speakers yesterday flagged TK as an important area given that two-thirds of the people on the planet are living in survivals economies, that is neither developing or market-based economies. Most people on the planet are living in poverty. And second of all most of the speakers yesterday, with the exception of biomass energy, seemed to be skewing their presentations to high-tech, modern technology, research laboratory, IT. Top-down, north-south type of science and technology. And not the demand-driven, bottom-up, participatory empowering type of science and technology transfer that is required to achieve the greening stage of globalization, and coherent logic that we want our recommendations from this conference to address. And I may want to come back to the word logic in a moment as there are two types of logic that need to be addressed - that of the traditional and that of the modern, even not post-modern type.

At the classical, global, UN-type of sustainable development, environmental arena we see an enabling multi-lateral policy environment in which traditional knowledge policy initiatives are maintained and further developed such as in the WIPO, UNCCD and CBD. If I understand my boss, Mr. Diallo, correctly yesterday he was calling for a policy forum that balances the work of the World Trade Organization and the Mr. Diallo was calling for some type of requires a careful analysis of the culture-specific division of roles and power relationships which determine the possible roles of innovators and the extent to which inventions are shared amongst conglomeration of the 250 environmental treaties that we see out there in our landscape.

Now what is important here is how to inject the use of traditional knowledge, not the protection or legal aspects, but the promotion of the use and integrate of local science to the community through this current intergovernmental environmental policy arena where we find ourselves sitting today.

In order to do that we have to understand a bit about the differences between modern science and technology and traditional knowledge.

Traditional and local knowledge are part of a complex, multi-purpose system and does not consist of a simple list of agro-based technical solutions, and be limited to a series of different applications varying according to the results obtained. Their efficacy depends on the interaction among several factors. They must be carefully taken into account if the success accomplished in history in some cases by means of traditional knowledge and its logic are to be understood for a contemporary application.

Each traditional practice is not an expedient to solve a single problem, but it is an elaborated and often multipurpose system that is part of an integral approach (society, culture and economy) which is strictly linked to an idea of the world based on the careful management of local resources. A terrace is a way to protect a slope, to reinstate the soil and to harvest water. It works within a social organization and a shared system of values that supports it and that is, in turn, based on it. During flood periods, in dryland areas what seems to be a network of narrow streets is an important system of flood diversion having different functions according to season changes.

Modern technology tries to be immediately efficacious by using the specialization of knowledge managed by dominant structures that are able to mobilize resources that are external to the environment. In the long and very long period, traditional knowledge proves functional by using a shared knowledge created and handed down by different generations and social practices and uses internal renewable input. Thanks to modern technology it has been possible to excavate certain historical wells in the drylands at very deep depths by pumping ground water. The results can be rapidly checked but the local resources can be depleted and sometimes, as time goes on, the resources can be completely depleted. On the other hand, traditional knowledge uses water harvesting systems or surface aquifers by using gravity or by adopting catchment systems that enable the reproduction of the resource and its durability in the long run.

Whereas traditional technological methods use separation and specialization, modern knowledge applies combination and integration. According to the traditional idea, the forest, the agriculture and the town are three items completely separated because they fulfil different needs, such as: wood, food, house. Each item avails itself of a specialized scientific system: forestry, agriculture and town-planning. According to local knowledge, the plant heritage is not artificially separated from the forest that provides commercial wood and from the farming land that provides food (Shiva,1993). Forests, fields and dwellings are unitary ecological systems. The forest and the other marginal areas which are apparently non-productive areas, like the steppes and the marshlands, provide considerable amount of food and water, fodder and fertilizers for agriculture. It is also possible to live in these marginal areas. The traditional town, in its turn, integrates with agriculture thus replacing, in desert areas, the forest for obtaining fertilizers that are produced by organic wastes of the inhabitants and for the production of the water caught on the roofs of the houses. As a result, the humus produced in the fields gives the soil its colloidal quality which is necessary for building houses in adobe towns. The hole made by excavating the land is used either as a gutter for water, or as a hole for the transformation of dung into humus, or as orchard whose contour is protected by excavation walls. Therefore, the activities are carried out in this feedback cycle where the result of one activity is the basis for the realization of the other. The architecture fulfils this need in every single detail.

This principle which is very similar to the functioning of nature where each residue of a system is used by other systems, where the idea of waste or the possibility to resort to external resources does not exist, has allowed the survival of people throughout history. Multipurpose techniques have been successful even in hard times. The collaboration and the symbiosis by reusing what is produced within a system enabled the autopoiesis, the self-reproduction, the self-propulsive development, which does not depend on exogenous or occasional factors.

When this logic is supported by strong cohesion between society, culture and economy, a positive development is obtained in history. The synthesis between traditional knowledge and social systems leads to forms of intensification by appropriately using the resources and entailing positive status changes, thus realizing rural or urban ecosystems. This process enabled the success of important civilizations based on traditional techniques, thus producing important socio-economic results.

Besides the interaction among environmental, productive, technological and social aspects, we should take into consideration both aesthetic and ethnic values. The traditional procedure works in harmony with the landscape, thus trying to meet the traditional aesthetic needs. A tool for water harvesting or conduction is not only a technical structure but it is also a beautiful structure. The oases are productive systems but at the same time they are places of contemplation and rest. Likewise in the south of Italy, the small farmlands of the desert are called gardens, thus eliminating the difference between orchards and gardens. The constructions and the methods often have a deep symbolic meaning that draw continuous analogies between technique, art and nature. The water repartition systems in the Sahara desert are reproduced on the patterns of carpets and in women's hairstyle. They are complex symbols linked to life, fertility and generations. Spiritual principles sanctify the rules thus guaranteeing their dissemination. This is the case of the holy woods in Africa that have limited access, or of taboo goods, that are practices which guarantee forest reinstatement, environmental and soil resources as reserve for nature and human communities.

Therefore, the traditional technique is an integral part of a set of links and relationships that is strongly integrated and supported by symbols and meanings. The traditional technique is performed thanks to a cultural structure that is socially shared: it is the system of the local historical science and knowledge.

Therefore, it is wrong to isolate the single technology, which always relates to a context and is not only linked to an environmental situation but also to a precise historic period or to a complex social structure. These remarks are necessary in view of the dissemination, the reproducibility or the reuse of contemporary forms of traditional techniques. Actually, it is not true that a traditional technique always gives positive results in different situations and periods. The "slash and burn agriculture" or the "shifting agriculture" enabled the survival of human groupings for very long period of time in perfect harmony with resources but it can also turn out to be catastrophic if it is applied in a different environmental and demographic context.

Traditional knowledge must not be meant as a set of expedients to be replaced by traditional background, but it must contribute to the formation of a new paradigm. What is possible to learn from traditional and local knowledge is not a series of miracle solutions that could be able to act in the same logic of modernity. It is the method on which it is based that can be put forward again by means of modern technologies.

STRATEGIES FOR POLICY FORMULATION

Important policy elements can be learned from the systemic and complex character of traditional knowledge and traditional societies which can be embedded into the globalization policy context for science and technology.

Optimistically speaking, traditional models of development can be revitalized and provide a basis for developing a new technological paradigm which might be the result of recommendations from best practices or guidelines. Sometimes these feed into policy formulation and sometimes out of policies And here are some general examples of strategies to integrate traditional and modern knowledge were suggested:

1) To adopt a bottom-up approach in research and development which puts the farmer-innovator at the centre; Now there are a number of problems that are typically associated with innovation at the local level. Those result primarily from the conservative nature of farmers.

2) External scientific and technical experts should learn to listen and to enter into dialogue with the knowledgeable local actors;

3) Mechanisms to share and disseminate traditional knowledge and its innovations horizontally can be set up and supported (e.g. regional radio programmes, farmer-to-farmer networks);

4) There is a relationship between the capacity of decision-making and the capacity of realizing innovations. Therefore, empowerment is an essential dimension of encouraging innovations, especially among women; Here I am thinking of an example of participatory GIS systems whereby villagers build three dimensional models of the landscape, understanding the land in a plastic, modeling sense before moving on to digital systems.

5) Local entitlements on the use and management of natural resources should be strengthened and consolidated when modern knowledge or technologies enter into traditional settings;

6) Mechanisms to valorise and recognize the achievements of knowledgeable local actors and inventors should be developed;

7) Truly participatory bottom-up approaches to development are necessary. Their adaptation includes a change of attitude among scientists and technology transfer experts. The role of external (national and international) experts should be critically assessed;

8) Because women are essential managers of natural resources and therefore possess extensive traditional knowledge concerning the natural environment, extension services should have a better gender ratio. Furthermore, the relationship between gender, science and technology should be carefully investigated. There are very few women researchers and recognized innovators. The role of science in traditional technology has thus to be viewed from a gender perspective;

9) Horizontal dialogues between members of different cultures and an understanding of the cultural specificity and diversity in which traditional knowledge is reproduced and expressed (in practices, in festivities, in rituals etc.) are two key elements of the anthropological methodology which permits the understanding of "agri-cultures" as complex systems of knowledge and practice. A "culture to culture" relationship should replace the "I (expert) will capacitate and instruct you" approach.

THE 4 CRITIQUES OF TRADITIONAL KNOWLEDGE

1. TRADITIONAL TECHNIQUES CONSTITUTE A SPECIFIC AND LIMITED SERIES OF TECHNICAL SOLUTIONS

The proposal is contradicted by the very same definition of traditional knowledge as an integrated learning organization, a complex system with multifunctional characteristics, an integral part of the collective identity's as well as social cohesion's construction process. Taking it as a series of expedients to solve specific problems is reductive and deceptive. Each traditional practice responds to a specific necessity but is highly integrated with the environmental and social context, and is part of a complex whole of social, ecological but also symbolic and aesthetic values.

2. THEY ARE NOT TECHNOLOGICALLY COMPETITIVE, WITH THE RESULT THAT THEY ARE TECHNOLOGICALLY INEFFICIENT AND LESS PRODUCTIVE THAN MODERN TECHNOLOGIES

This critique is not justified since there is no reason to consider traditional techniques as less competitive, inefficient or unproductive than modern techniques. Traditional technology considers a series of contextual factors omitted by modern techniques, and results differ. The procedure is sometimes not that immediate and needs more work, however, this does not represent a negative feature in many countries that face unemployment problems. In order to assess the efficiency of a process, both internal and external aspects are considered. Indeed, the application of a technique determines the effects from the cradle to the grave of the necessary use of resources and has more general consequences on the entire economic, social and environmental system. These interactions are not taken into account in a modern technique based on specific and immediate yield criteria. On the contrary, traditional techniques are selected and accepted through a process of environmental, historical and social comparisons. Their efficiency is appraised according to their validity over the long term, their contextual benefits and their full sustainability.

3. TRADITIONAL TECHNIQUES CONCERN THE DEVELOPING WORLD AND ARE MARGINAL COMPARED TO GREAT ECONOMIC AND TECHNOLOGICAL PROCESSES

This is contradicted by the fact that the continuing consolidation and stabilization of the role of traditional technologies in society and in the economy can be verified, specifically in the more advanced countries. The traditional values, manufacturing practices and artisan capacities of traditional technologies are the basis on which is founded the great added value of yields of enormous economic importance for many advanced countries. In particular, typical alimentary produce (such as oil, cheese and wine) safeguards the quality of the land, both aesthetic and environmental, since old production systems are available thanks to the maintenance of traditional techniques of soil management. In the same field, increasing agricultural yields and quantities of biologically controlled meat are the result of even more interest in traditional techniques of cultivation and breeding. These considerations are true even in other sectors from quality gadgets to haute couture and from real estate to the building market. It is an advantage for the most renowned manufacturers to be able to list the traditional techniques they use and the success of many companies is actually due to having incorporated traditional techniques into their processes or to be located in traditional environments or historical centres.

4. THEY ARE PROPOSED BECAUSE OF AN IDEOLOGICAL ANTI-TECHNOLOGICAL VISION

The fourth critique is to be rejected since, even if in the traditional knowledge movement there are some anti-technological components, on the whole, it is not true at all. Traditional knowledge is not proposed because it contains less technology compared to the conventional ones, but because it has better results, technologically speaking, compared to the determined environmental and social context. Sometimes, it has the most refined technologies, some other times, it is very simple but still more appropriate, and is ecologically compatible and locally manageable. Furthermore, traditional knowledge is re-proposed through each single possible innovative use that is in conjunction with modern technologies which can operate within the same logic. As a matter of fact, it is the principle of traditional knowledge that is useful to spread and copy not the technique itself. This is actually possible thanks to the use of the most advanced technologies in the field of eco-energies, recycling, pollution-free production, and maintenance of old procedures thanks to low-impact processes of mechanization that are self-manageable.

CONCLUSION

For me, the benefits of science and technology are multifaceted according to the scales through which they can be observed. Within a macro-economic globalization framework based on free-market econometric principles, traditional technologies can be considered as marginal. However, from local and environmental policy points of view, traditional knowledge and its technology plays a primary role.

Akihiro ABE

Professor
Center for Nano-Science and Technology
Tokyo Polytechnic University

After working as a research chemist in private industry, Akihiro Abe joined Tokyo Institute of Technology in 1977. Upon retiring from that position in 1994, he moved to Tokyo Polytechnic University (Japan) and Polytechnic University (NY, USA). He is Chairman of the Board of Directors of the Kigetsu-Shoin scholarship foundation (since 1969) and served as President of the Society of Polymer Science, Japan (SPSJ, 1992–94). Dr. Abe has received a number of awards and honours, including the Award for Distinguished Service in Advancement of Polymer Sciences (1998, SPSJ), P. J. Flory Award in Polymer Science (2001), and Doctor Honoris causa Degree in Chemistry (2006, Russian Academy of Sciences). He holds a PhD in Chemistry from Polytechnic Institute of Brooklyn (Polytechnic University).

LINKING GLOBALIZATION, SCIENCE AND TECHNOLOGY FOR PEACE AND SUSTAINABLE DEVELOPMENT

UNU/UNESCO International Conference
Globalization: Challenges and Opportunities
for Science and Technology

Workshop: Linking Globalization, Science and Technology
for Peace and Sustainable Development
— 3. Society and Policy-making -—

A Proposal of A global project "Total Study of the Earth"
involving UNU/UNESCO, ICSU and IUPAC
in the age of "Science for Society"

August 23-24, 2006 Yokohama Pacifico, Yokohama

Akihiro Abe
Tokyo Polytechnic University
Nano-Science Research Center

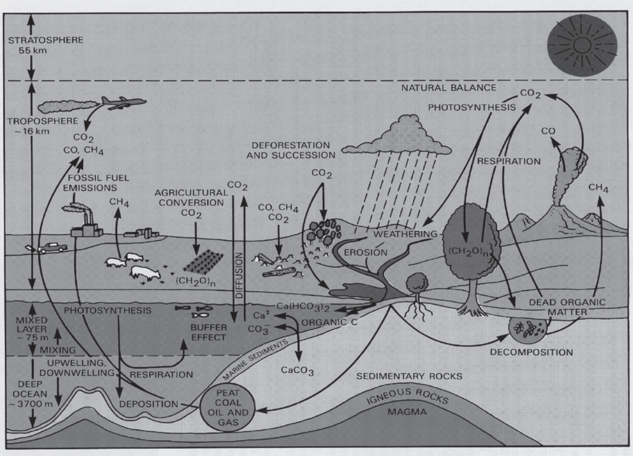


Figure 16. The carbon cycle. NASA Eos Committee Report

The earth is essentially a chemical planet controlled by

1. Mass Conservation Low
2. Energy Conservation Low

For a given energy consumption, we are obliged to pay certain entropy bill in terms of either heat or low-energy materials. The environmental problems are typical examples. The principle applies to all energies regardless of their source: fossil, nuclear, water power, sunshine, etc.

It does not matter whether the arguments are from materialism or dualism. Those who are not materialists should also accept the results.

A pessimistic view on the human civilization:

Human-beings have succeeded in establishing a modern civilization by learning the use of energy.

For humanity to last longer, Chemical sciences* must play a leading role in the society.

Otherwise, sooner or later the humans would possibly come to the cease of existence in ignorance of the entropy concept.

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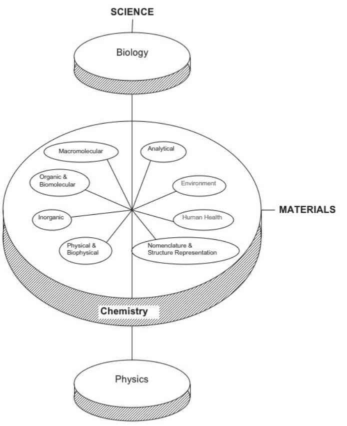
*Chemistry is the discipline studying the consistency between energy and matter (materials), the two being like the two sides of a sheet.

IUPAC DIVISIONS



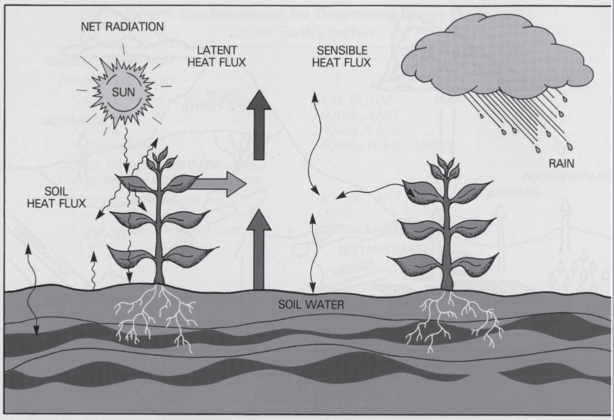
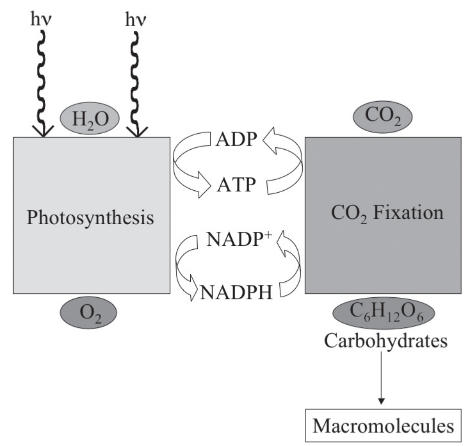
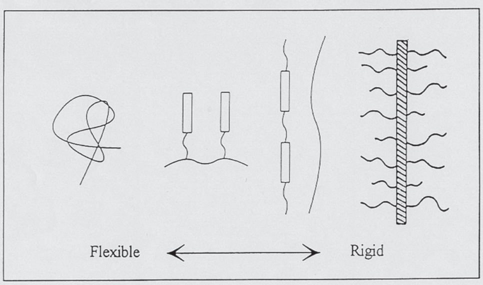


Figure 14. Canopy model showing components of heat, radiation, and moisture balance at the soil surface.



polymer concept = attributes of long-chain molecules



$$S^{conf} = k \ln Z + kT(d\ln Z / dT)$$

$$Z = J^* U_1^{(n)} J$$

A modern role of Chemistry :

These days most chemists are working in their own laboratory isolated from the mother nature.

We, chemists however should realize that we are obliged, more than anyone else, to understand all aspects of the materials-energy circulation taking place on the earth. (cf. ACS Project, "Chemistry in Context: Applying Chemistry to Society" 5th Ed., McGraw-Hill, NY, 2006.)

This applies to all chemists regardless whether he/she is a technological optimist or an environmental pessimist.

After all these considerations, I am inclined to propose a large-scale international collaboration as a contribution to the world society by means of the knowledge indigenous to chemistry (materials-energy balance).

A Proposal of a Long-Term Project: "total studies of the earth" in terms of the materials-energy balance:

A standing committee sponsored by UNU/ UNESCO and/or ICSU in collaboration with IUPAC and other scientific organizations.

After a hard work over an extended period, I am sure they will come up with a collective (semi-quantitative) picture of our planet in terms of the materials-energy balance for both living and non-living systems.

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Project (continued):

In these studies, all branches of chemistry including thermodynamics (the energy-entropy relations) must be involved.

Collaborations with other disciplines such as biology and physics are of course inevitable. A world-wide cooperation with the other organizations is a prerequisite.

A global project advocated by UNU/UNESCO and/or ICSU would possibly increase the number of scientifically-motivated people who can voluntarily contribute by observing the living and non-living systems in their surroundings. The limitation arising from the availability of professional scientists may be complemented by their participation.

The most difficult part of this program would be to find a right person(s) to lead the project. I hope someone will raise his/her hand.

Concluding Remarks:

I often feel a gap between what scientists (chemists) think important and the needs of the society. I have proposed a project as a start toward a new S&T to fill the gap. A total study of the earth will eventually demonstrate the capacity (highly possibly the limitation) of the earth as a material-energy circulating system.

The importance of peace (a life with minimum entropy emission) may be strongly supported on the scientific ground, which should inevitably affect human civilization, culture (our life-style) as well as various policies.

A MODERN ROLE OF S&T FOR SOCIETY:

- Where do we come from?
  - Most recently from monkey.
- What are we?
  - We should spend more resources (money and manpower) on this subject: a total study of the earth.
- Where are we going?
  - Move ahead more cautiously!

Comment: this might imply a conflict between the DNA strategy and the human wisdom.

The Long-term Project proposed may yield some secondary, but immediate merits such as

1. The project may provide some useful academic interaction with the ESD program of UNU/UNESCO.

2. The ambiguity associated with the use of terminology "sustainability" or "sustainable development" would be cleared up by these steady efforts.

3. The activities may be expanded by involving volunteer (amateur) scientists. (The limitation arising from the availability of professional chemists may be complemented by their participation.)

WORKSHOP 3 REPORT SOCIETY AND POLICY MAKING

Rapporteurs:

Catherine Monagle, Clarice Wilson and Christopher Kossowski

Chair:

A.H. ZAKRI, Director, UNU Institute of Advanced Studies (UNU-IAS)

During this workshop four presenters addressed the topic of society and policy making from different perspectives.

Dr. Issa Kalantari underlined the linkages between disparities in access to the benefits that science and technology brings with the international politics of globalization, the immense power of the west of informing the agenda, including the agenda of international organizations, and the critical need for improvements towards accountable governance in developing countries. Dr. Kalantari identified linkages between governance, science and the major questions of our time, including poverty, sustainable development, human rights, peace and security. Dr. Kalantari emphasized the role of citizens in pressing governments to respond to problems that affect their day-to-day life. Improved participation and influence by the public, and enhancing a meaningful role for civil society and NGOs in developing countries are particularly important. Dr. Kalantari suggested that it is critically important that the UN system focus comprehensively on eradicating corruption – this being a primary obstacle to the improvement of the well-being of the majority of the world's population. He also proposed that the international community looked at options for an international tax on practices that strip the earth's resources.

Dr. Douglas Pattie brought his experience from the UN Convention to Combat Desertification, but, today, chose to address strategies to Integrate Traditional and Modern Knowledge. He reminded us that two thirds of our world live in survival economies, and of the importance of focusing on the needs of the majority. He noted, thus far, discussion had focused more on top-down approaches that use high-end technology. He suggested that we need to consider the role of traditional knowledge as central to ensuring the relevance of science and technology. Thus, it is more important to focus on the use of traditional knowledge rather than its protection from an intellectual property perspective. Among his suggestions, he recommends experts listen to local knowledge-holders, adopt a participatory bottom-up approach, with farmer-at center, and identify mechanisms to share TK (or traditional knowledge). Dr. Pattie suggest that in exploring the relationship between policy decision-making and capacity, empowerment is essential.

Professor Akihiro Abe of Tokyo Polytechnic University emphasized that we all can benefit from a better understanding of the entropy equation which chemical scientists are well familiar with, yet ill-practiced in developing to society and policy makers. He suggests that chemical and material scientists can contribute to understanding of science and the limits to the earth's resources in policy making. He suggested chemical and materials scientists have much to offer broader debates and policy making. Rather originally, Professor Abe identified Peace as a minimum entropy equation.

Professor Abe introduced a proposal for a global project titled Total Study of the Earth-Involving UNU/UNESCO, ICSU and IUPAC in the Age of Science for Society.

As part of this process re recommends that a standing committee for the creation of a collective picture of our planet from the chemistry perspective sponsored by UNU/UNESCO and of the ISCU* International Council for Science (in collaboration with IUPAC*International Union of Pure and Applied Chemistry) be established. The project would involve an active observational component with scientifically-motivated people contributing by observing living and nonliving systems in their surroundings.

The underlying belief informing the project is that peace is essential and needs to be kept in mind when engaging in scientific endeavors.

Dr. Taeb of the UNU-IAS delivered the presentation for Professor K.R. Sreenivasan of ICTP. He outlined the history of globalization and suggested that the universal values of science make it, in some sense, a natural ally of globalization. Sreenivasan identifies that while there is emerging resistance to globalization – terrorism, extremism, provincialism, protectionism – technology is developing in a way which cannot be reversed.

He identified the role of globalization in contributing to the brain drain of scientists in the developing world, and suggested that what is key it to enable short term mobility for scientists to develop expertise and participate in exchange of information with overseas experts and institutions, while developing incentives for them to return home. He suggested that thoughtful people now agree that building scientific capacity in all parts of the world is essential.

Professor Sreenivasan identified that intellectual property is potentially a tool for the benefits of large parts of the poor population of the planet, yet identified that currently it is not the poor nor developing countries benefiting most from intellectual property rights nor the technologies to which they relate. Professor Sreenivasan identified that it is important for enhancement of the connection between science and wealth creation.

Finally, and critically, Professor Sreenivasan emphasized that given the earth's finite resources, poor countries cannot follow the same technological parth that industrial countries followed. They must look now for alternative approaches that will put them in a strong position into the future. For this, they need access to science and technology.

Discussions focused on the need for policy makers and scientists to work together at an early stage. The Rector of the United Nations University suggested that in discussing globalization people bring different understandings of what globalization means. Analysis of the consequences of globalization in specific contexts must inform effective discussion and the identification of strategic approaches.

The Challenge for the United Nations System is to facilitate effective and meaningful exchange between policy makers and scientists at an early stage, and in specific contexts. The dilemma between analytical scientific approach and policy approach is for scientists and policy makers working together, not in general terms but targeted towards specific crucial topics. Each field will have a different type of discourse, needing to bring different people together to come to conclusions. These are steps that can be taken at both the national and international levels.

WORKSHOP SESSION 4
SCIENCE AND TECHNOLOGY EDUCATION FOR SUSTAINABLE DEVELOPMENT

Monthip Sriratana TABUCANON

Deputy Permanent Secretary
Ministry of Natural Resources and Environment, Thailand

Monthip Sriratana Tabucanon has extensive professional experience in the field of environmental management. She received postgraduate education in environmental engineering and management in Thailand and Japan, and professional training at universities in the USA. She established the Environmental Research and Training Centre in Thailand with support from the Government of Japan. In her current capacity, she oversees the promotion of natural resources conservation and environmental quality in Thailand. Internationally, she plays an important role in strengthening regional cooperation in ASEAN and the Greater Mekong Sub-region (GMS) and in promoting public participation in environment and natural resource management, environmental dispute prevention and resolution, and the promotion of education for sustainable development. She is a member of the Parliamentary Committee on Natural Resources and Environment, Office of the Parliament, and IUCN Regional Councillor for South and East Asia.

SUSTAINABLE DEVELOPMENT AND THE SUFFICIENCY ECONOMY: ROLE OF SCIENCE AND TECHNOLOGY

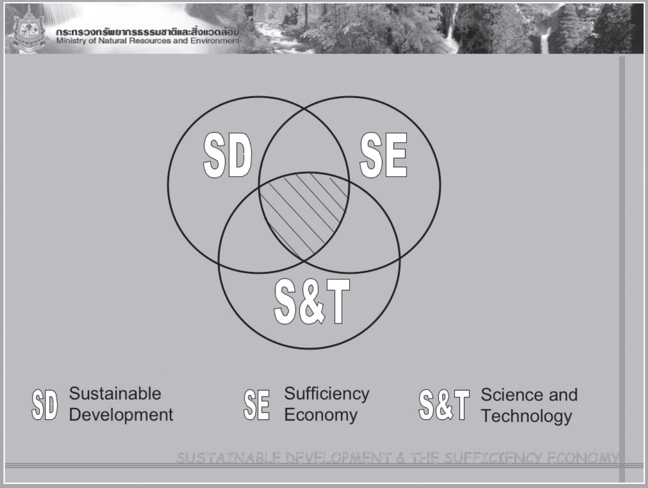
ABSTRACT

Advances in science and technology have been recognized as among the vital prime drivers of globalization. These advances have made the world smaller through rapid communication, faster and accurate information flows, and reliable knowledge exchanges, among others.

But in the midst of increasing globalization, a new development paradigm has emerged – one which embraces the global concern on sustainability. Sustainable development is designed to serve the needs of all peoples, enough and forever. But in as much as science and technology have propelled globalization, there is no doubt that they also serve as imperative tools in supporting sustainable development processes.

Science and technology education must be addressed widely – both in the formal and non-formal sectors, and both in the formal and informal curricula. The critical and salient issues that make science and technology education effective for sustainable development need to be analyzed. The case of Thailand will be considered, with the hope that the issues would have implications to the rest of the world, and that lessons can be learned from the Thai experience. Particular reference will be made to His Majesty, The King of Thailand's new theory and the Sufficiency Economy Philosophy, as well as to His Majesty's effective teaching and learning approaches used throughout his reign. The Sufficiency Economy Philosophy takes a middle path approach towards sustainable development and is based on the foundations of moderation, reasonableness and resilience. The philosophy is underpinned by knowledge and morality.

These salient issues are then linked to the overall approach of sustainable development.



Sustainable Development (SD)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

-World Commission on Environment and Development Report, 1987

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SD as an Approach

SD is an approach – it is not a discipline. Indeed, SD covers multiplicity of disciplines.

SD is not one sector – it cuts across sectors, namely Economic, Environmental and Social/Cultural

SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY

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SD in a Holistic View

SD views development in a holistic perspective integrating natural and social sciences, technology, planning, management and allied fields

Hence, the role of Science and Technology (S&T) is essential in Education for Sustainable Development (ESD)

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S&T in Formal Education

- S&T subjects should use examples and demonstrations using SD to illustrate theories. This applies to all levels of the formal education sector – primary, secondary and tertiary

SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY

S&T in Non - Formal Education

- The Non-formal Education institutions should rely on S&T to impress upon society the importance of SD. Impartation of SD issues can be more convincing if the language of science and the mechanics of technology are used.

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Research in S&T

- Traditional knowledge is insufficient to advance the SD concept. Institutions of higher education, as well as dedicated research institutions, must invest in new research which put SD as the core paradigm. This applies to all disciplines of science, engineering and allied fields (planning and management)

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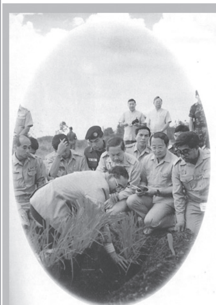
The Sufficiency Economy Philosophy (SEP)



- His Majesty, the King of Thailand developed and introduced SEP in all Royal Projects in Thailand (Since 1974)
- SEP is a tool for achieving SD, especially in poor rural areas.

SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY

New Theory and the SEP

- SEP approaches SD utilizing systems approach, scientific thinking and appropriate technology
- Applies the concept of "Living in balance with nature"

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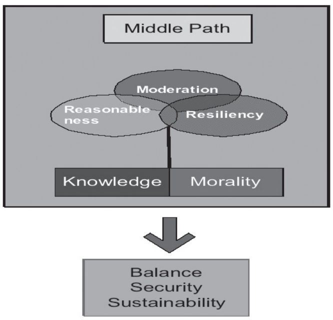
Sufficiency Economy Philosophy



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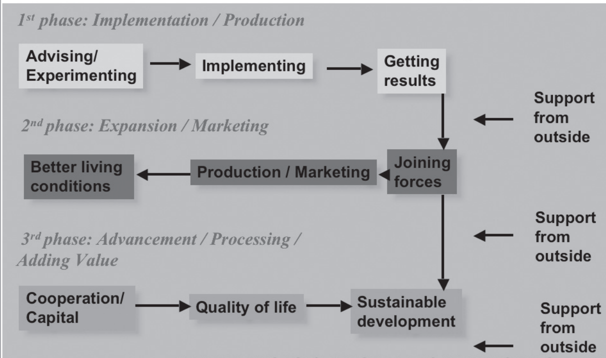
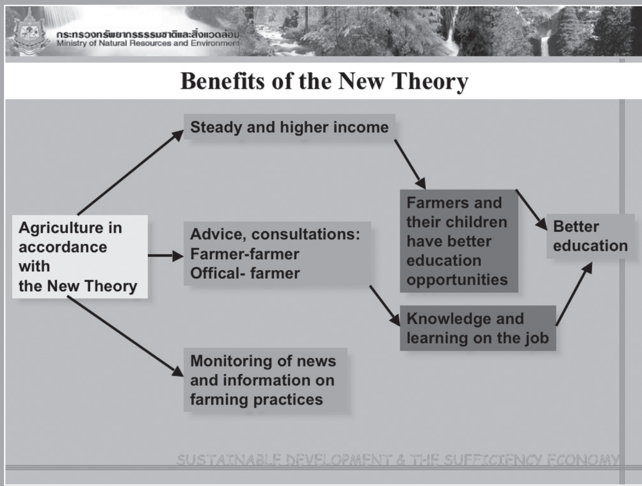
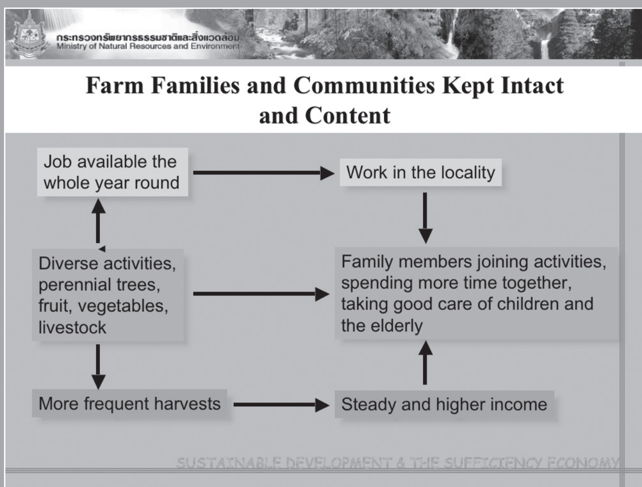
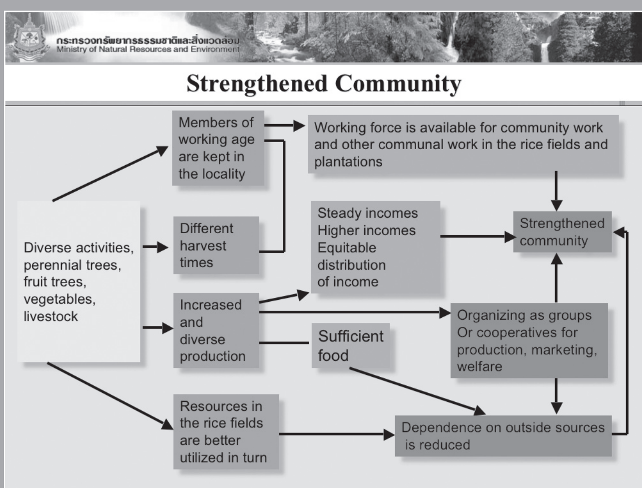
Procedure of the New Theory

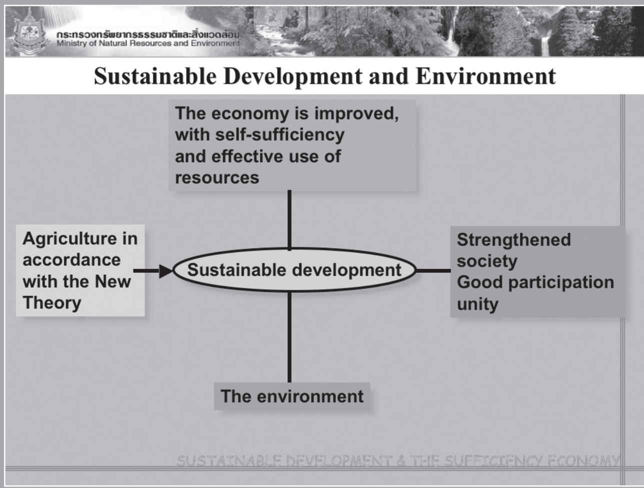


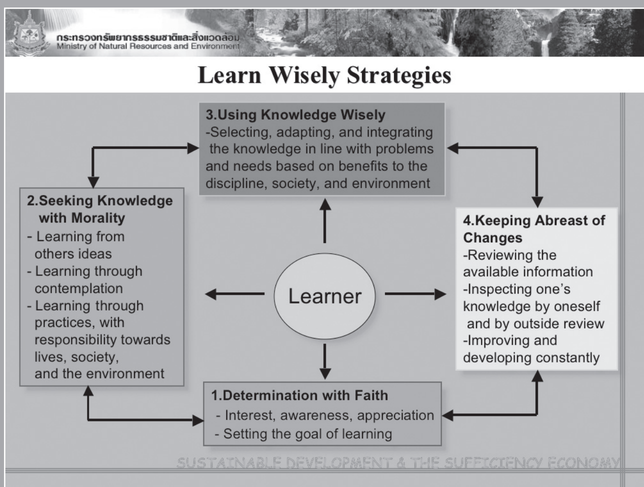
SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY

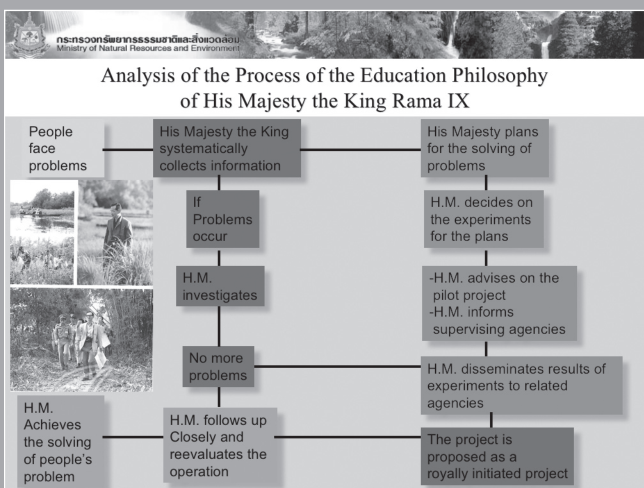

กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Benefits of the New Theory
Steady and higher income
Agriculture in accordance with the New Theory
Advice, consultations: Farmer-farmer Offical- farmer
Farmers and their children have better education opportunities
Better education
Knowledge and learning on the job
Monitoring of news and information on farming practices
SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY


กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Farm Families and Communities Kept Intact and Content
Job available the whole year round
Work in the locality
Diverse activities, perennial trees, fruit, vegetables, livestock
Family members joining activities, spending more time together, taking good care of children and the elderly
More frequent harvests
Steady and higher income
SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY


กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Strengthened Community
Members of working age are kept in the locality
Working force is available for community work and other communal work in the rice fields and plantations
Diverse activities, perennial trees, fruit trees, vegetables, livestock
Different harvest times
Steady incomes Higher incomes Equitable distribution of income
Strengthened community
Increased and diverse production
Sufficient food
Organizing as groups Or cooperatives for production, marketing, welfare
Resources in the rice fields are better utilized in turn
Dependence on outside sources is reduced


กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Sustainable Development and Environment
The economy is improved, with self-sufficiency and effective use of resources
Agriculture in accordance with the New Theory
Sustainable development
Strengthened society
Good participation unity
The environment
SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY


กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Learn Wisely Strategies
3.Using Knowledge Wisely
-Selecting, adapting, and integrating the knowledge in line with problems and needs based on benefits to the discipline, society, and environment
2.Seeking Knowledge with Morality
- Learning from others ideas
- Learning through contemplation
- Learning through practices, with responsibility towards lives, society, and the environment
Learner
4.Keeping Abreast of Changes
-Reviewing the available information
-Inspecting one's knowledge by oneself and by outside review
-Improving and developing constantly
1.Determination with Faith
- Interest, awareness, appreciation
- Setting the goal of learning
SUSTAINABLE DEVELOPMENT & THE SUFFICIENCY ECONOMY


กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม
Ministry of Natural Resources and Environment
Analysis of the Process of the Education Philosophy of His Majesty the King Rama IX
People face problems
His Majesty the King systematically collects information
His Majesty plans for the solving of problems
If Problems occur
H.M. decides on the experiments for the plans
H.M. investigates
-H.M. advises on the pilot project
-H.M. informs supervising agencies
No more problems
H.M. disseminates results of experiments to related agencies
H.M. Achieves the solving of people's problem
H.M. follows up Closely and reevaluates the operation
The project is proposed as a royally initiated project

Karl HARMSEN

Director

UNU Institute for Natural Resources in Africa (UNU-INRA)

Dr. Karl Harmsen was appointed Director of UNU-INRA in February 2006. Prior to his appointment he served from 2002 to 2005 as Director of the Centre for Space Science and Technology Education in Asia and the Pacific in Dehradun, India. He was Professor of Environmental Systems Analysis (2001–2002) and Rector (1997–2000) at the International Institute for Geo-information Science and Earth Observation (ITC), Enschede, The Netherlands and was Executive Director (1994-1996) of the West and Central African Programmes with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Director of the ICRISAT Resource Management Program in Hyderabad, India (1992–1994), and before that he was Director of the Institute for Soil Fertility, Haren, The Netherlands (1986–1992). Dr. Harmsen holds Ph.D. and M.Sc. degrees from the Agricultural University, Wageningen, The Netherlands.

SUSTAINABILITY NATURAL RESOURCE MANAGEMENT

INTRODUCTION

The title of this conference and the title of this particular workshop provide some guidance for papers to be presented in this workshop. The keywords are: (1) globalization, (2) science and technology, (3) education, and (4) sustainable development. Clearly, these are wide-ranging topics and, in addition, notions such as 'globalization' and 'sustainable development' are not very sharply defined and may mean different things to different people.

The UNU Institute for Natural Resources in Africa (UNU-INRA), Accra, Ghana, deals primarily with strengthening institutional capacities for research and education in sustainable management of natural resources in Africa. Hence, in order to make a somewhat focused and hopefully meaningful contribution to the discussion on the topic of this workshop, the emphasis in this paper will be on the notion of 'sustainability' in relation to management of natural resources (NRM).

Sustainable development has been defined by the World Commission on Environment and Development (WCED) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The report of the WCED, published in 1987, is also known as the "Brundtland Report", in recognition of the chairperson of the WCED, Gro Harlem Brundtland. The definition emphasizes the inter-generational equity, but also a fair distribution of wealth among all nations in the world today, through "meeting the needs of the present". The latter is obviously not the case in the world today and the recognition of this is reflected in the adoption of the Millennium Declaration by the UN General Assembly in September 2000. This declaration and its embedded Millennium Development Goals (MDGs) can be seen as a practical way of achieving a world where "the needs of the present are met" in an equitable and fair fashion.

Based on the Brundtland definition of sustainable development, the sustainable management of natural resources in the context of sustainable development would thus assume that natural resources are managed in such a way that (1) a livelihood is provided to the actors in the management process, (2) that future generations can make the same or similar use of these resources, and (3) that non-renewable resources are managed in a rational and conservative way, with an emphasis on recycling and exploring alternatives that make use of renewable resources. What this definition tries to capture is that there are two main aspects to sustainable NRM: a socio-economic aspect and an environmental aspect. In addition, there is an aspect of inter-generational equity: future generations should be able to make use of the bio-physical environment in much the same way as the present generation.

This paper will not deal with non-renewable resources such as fossil fuels and mineral resources, but is should be stated that even natural resources, such as soil, water, and biota (life forms), may include renewable as well as non-renewable components, depending on the nature of the resource, the geographic location and the time-scale considered. For example, some groundwater resources may be fossil and thus non-renewable, but when climate changes over a period of thousands of years, local climates in some areas may become wetter and thus recharge aquifers that were earlier considered to contain 'fossil water'. As another example, soil is essentially a non-renewable resource on a time scale of, say, 50-100 years, except possibly in areas where active sedimentation (water, wind) takes place or can be induced. However, on a time scale of thousands of years, new soils may be formed under suitable climatic conditions. Similarly, biological resources (plants, animals) may disappear, but on the time scale of evolution new life forms may develop, containing genetic materials similar or equal to the materials that were lost in an earlier stage of development of life on earth.

This paper will further focus on the bio-physical rather than the socio-economic aspects of sustainable NRM in relation to sustainable development, but it is understood that the socio-economic aspects are as important, if not more important in many cases, as the bio-physical aspects in achieving sustainability. If a natural resource management system is not economically viable or does not provide a livelihood to a farmer and his family on a sustained basis, then such a management system is not sustainable.

Sustainable NRM will be discussed in the context of 'development', that is, the objective of natural resource management is to achieve, or contribute to, sustainable development. The most important economic activity related to NRM in rural (= nonurban and non-industrialized) areas is 'agriculture', encompassing cultivation of food and cash crops, pasture management, forestry, agro-forestry, livestock-based systems, fishing and fish-farming, etc. Other economic activities in rural areas include tourism and recreation, and extraction of minerals (mining), among others.

The focus of this paper is further on the science and technology basis of sustainable NRM or 'sustainable development'. In the discussion we will touch briefly on opportunities and challenges created by 'globalization' with regard to science and technology education for sustainable development.

THE EMERGENCE OF THE CONCEPT OF SUSTAINABILITY

In order to better understand what is meant by sustainability it may be useful to consider the developments and events, in particular in Western countries, that have contributed to the emergence of the notion of sustainability. The following overview highlights a few developments and events that have contributed to the concept of sustainability, can be clustered under four headings:

1) Environmental issues

2) Limits to economic growth

3) Biodiversity

4) Social issues

ENVIRONMENTAL ISSUES

Concern about the environment is not a new phenomenon. For example, the famous speech by Chief Seattle in 1854 raised several important issues related to environment and nature and indicated clearly how perceptions differed between the indigenous Americans and the Western settlers. However, it appears that this speech did not reach the general public until the 1960's when concern about the environment developed into a major issue in the western world.

The discussion about the quality of the environment had clear international dimensions from the outset, and culminated in major international conferences such as the UNCED conference in Rio de Janeiro in 1992 and the WSSD in Johannesburg 10 years later.

Early on, cases of acute poisoning by cadmium and mercury in Japan (Itai-Itai disease and Minamata Bay) drew a lot of attention. After the heavy metals, the attention shifted to the organic micro-pollutants, which posed a threat to the quality of natural waters and drinking water. This was then followed by many other compounds, including nitrogen and phosphorus, as sources of pollution of natural waters.

In a number of cases the pollution of the environment was caused by intensive, high-input agriculture: Residues of pesticides, herbicides, nematicides, etc., in surface waters and groundwater, cadmium in soils where phosphate fertilizers had been applied, and copper in soils where pig manure had been applied. Nitrogen and phosphorus caused eutrophication of surface waters and later on were also found in groundwater. Ammonia volatilization from certain nitrogen fertilizers (e.g., urea) and animal manures was identified as one of the causes of the eutrophication of natural waters and acidification (acid deposition) of forests and natural habitats. Emission of nitrous oxides from temporally submerged soils was identified as one of the causes of the decomposition of the ozone layer, and so on. Parallel to concern about the chemical pollution of the environment, there was an increasing concern about the quality of food products: consumers wanted food that was grown without the use of biocides and chemical fertilizers. This trend resulted in the emergence of alternative forms of agriculture, such as "biological" or "organic" farming, or forms of agriculture based on anthroposophic theories (e.g., Rudolf Steiner).

Environmental concerns rank high on the sustainability-list, even though meeting certain (chemical or biological) environmental quality standards is not always a requirement for sustainability. For example, there is no reason why crops could not grow on soils that are polluted with heavy metals, such as lead or cadmium. What matters is the availability of these toxic metals to crops and this is often low or can be lowered through management practices, such as liming. All one would have to do is to make sure that heavy-metal contents of consumable parts of crops are below established food-quality standards. However, people generally feel that crops grown in a polluted environment should not be consumed and that, in turn, a sustainable agriculture should not pollute the environment. As a result, "sustainable agriculture" was often interpreted by the general public as a form of agriculture characterized by a reduced input of chemical fertilizers and biocides.

A lower input of chemical fertilizers could (to some extent) be compensated for by more biological nitrogen fixation (e.g., by legume crops), a more prolific incidence of VA mycorrhiza in order to increase P-uptake efficiency, more emphasis on the role of organic matter in soils, promoting the use of animal manures and organic residues, etc. The scientific expression of these trends was the research into "integrated nutrient management".

The trend to use less biocides resulted in an increased interest in alternative methods of weed control and in "integrated pest and disease management". The latter refers to a blend of methods of biological control, breeding for disease and pest resistance, and soil and crop management, such as the introduction of alternative cropping systems (intercropping, multiple cropping) and wider crop rotations, date of planting, etc.

As a scientific corollary of these trends there was an increased interest in the soil ecology or the functioning of the soil biosphere. Also there was an increased interest in interactions between nutrients and the incidence of weeds and diseases. For example, high N may increase the susceptibility to diseases, because the higher amount of biomass results in different microclimate under the crop canopy, which may be favourable to the development of diseases, etc.

LIMITS TO ECONOMIC GROWTH

During the 70's and 80's there was a perception among many scientists that there were limits to economic growth, posed by the presumed exhaustion of non-renewable resources (fossil fuel, minerals) and the pollution and degradation of the biophysical environment, in combination with the growing population and changing consumption patterns. This resulted among others in the reports of "The Club of Rome". The first report, The Limits to Growth, published in 1972, considered 5 major trends of global concern: accelerating industrialization, rapid population growth, widespread malnutrition, depletion of non-renewable resources and a deteriorating environment. Although the assumptions underlying the analysis and the method for understanding the dynamic behaviour of complex systems have been questioned, the report was very influential and contributed to the feeling among the general public that there were limits to economic growth.

Prominent in the discussion were the issues of renewable versus non-renewable resources and the development of new technologies. The general inclination was towards the use of renewable resources and recycling of non-renewable resources. Efforts to reduce the dependency on fossil fuel resulted in an increased interest in renewable sources of energy, such as sun, wind, tidal movement and the earth' warmth (geothermal energy). It may be noted that nuclear energy, although a clean source of energy from the point of view of emissions, was not generally considered an alternative to fossil fuels, because of finite resources of nuclear fuel and problems with the storage of nuclear waste products, as well as the risk involved in operating nuclear reactors. The latter was only strengthened after the Chernobyl accident.

With regard to agriculture, the discussion focused on substituting renewable for non-renewable resources, and in general to use less "external" inputs, as essentially all of these external inputs would require fossil fuels to be produced. This contributed to the emergence of "low external input sustainable agriculture" (LEISA). The move to use less fossil fuel resulted in a decreased use of heavy machinery and an increased interest in minimum tillage and zero-tillage techniques. This in turn resulted in an increased interest in the role played by the soil biosphere in producing a stable soil structure. Other external inputs that require fossil energy in their production include fertilizers, in particular nitrogen fertilizers. With regard to nitrogen fertilizers the trends were to decrease the overall use of nitrogen and to replace chemical fertilizers (substitution) by alternative sources, such as animal manures or other organic products, biological nitrogen fixation (symbiotic), crop residues, etc.

BIODIVERSITY

Organizations that are involved in the conservation of nature have been around for a century or more. Until recently they never attracted much public interest. The conservation of nature is to some extent a separate issue from the environmental quality. The latter is largely defined in chemical (abiotic) terms and has to do with the contents of hazardous compounds (heavy metals, organic micro-pollutants, biocide residues) in the soil, in natural waters and in our drinking water, in the air, in our food, etc. In principle, in a world where there would not be a single bird left, the quality of the air, soil, water and food could be excellent. On the other hand, birds are part of many terrestrial and aquatic food chains and ecosystems, and their disappearance would have an effect on these ecosystems, whereas the disappearance of birds in itself would probably be caused by pollution of the environment, such as the accumulation of biocides (DDT) in certain food chains, which nearly lead to the extinction of certain birds of prey in Western Europe. The point is, though, that although bird populations may to some extent reflect the quality of the environment, their presence itself does not necessarily improve the environmental quality (other than the well-being of bird watchers).

Nevertheless, even though conservation of nature is not identical to environmental quality, nature conservation got a tremendous boost from the environmental movement. Many people did not distinguish between the two issues and started being concerned about the disappearance of species in our natural environment: birds, mushrooms, butterflies, lichens, whales, etc. The interest in organizations like Greenpeace and the World Wildlife Fund grew enormously. In the Netherlands, the membership of the Union for the Protection of Nature grew from less than 100,000 to more than a million.

To some extent the conservation of "biodiversity" is the rationalization of this movement. People started recognizing that the disappearance of many life forms resulted in the loss of genetic diversity and that this genetic diversity in turn could be of (economic) interest to us, now and in the future. The importance of plant genetic resources had long been recognized, but the issue was now broadened to include other life forms, including those making up the soil biosphere.

The consequences for agriculture were in the first place a move to decrease the use of biocides. Obviously, the objective of using biocides is to kill certain life forms. As biocides could not be entirely eliminated from agriculture, the interest shifted from broad-spectrum agents towards chemicals that are selective for specific life forms. Also, the rate of decomposition of biocides in the natural environment became important, as well as the chemical behaviour and properties of the biocides and their decomposition products (residues).

The discussion concentrated on the trade-offs between effectiveness and environmental persistence of biocides: a biocide that breaks down quickly into non hazardous compounds may be less effective against a specific life form, but attractive from the environmental point of view; a biocide that is highly persistent may be effective against specified life-forms, but poses a hazard to the environment. Also, this trend resulted in an increased interest in integrated pest and disease management and in the study of the ecology of agro-ecosystems.

Other consequences of the interest in biodiversity were an increasing interest in the collection and conservation of plant genetic resources (in-situ and ex-situ), more interest in the genetic characteristics of wild ancestors and land-races, and an increased interest in intercropping, multiple cropping, and alternative and wider crop rotations.

SOCIAL ISSUES

The notion of sustainability also has a social dimension, as it assumes an equitable distribution of wealth in the present and intergenerational equity in the future. However, in many parts of the world, poverty, exploitation, and discrimination have persisted for ages and therefore it would be difficult to argue that systems based on, say, the exploitation of the rural poor could not be sustainable. Nevertheless, based on the Brundtland definition, issues such as poverty, discrimination, exploitation, or other forms of social injustice or deprivation, are contrary to the concept of sustainable development

The social dimension of sustainability may well be linked to a number of developments and events in Western countries during the post-World War II era: the democratization of the universities in the late 1960's, the emancipation of women, the decolonization process, the emancipation of all sorts of minorities claiming their rights, the end of the cold war, etc. Against this background there was a tremendous upsurge in extra-parliamentarian groups all over the world and in NGO's addressing a range of social issues.

"Globalization" became somewhat the rallying point of many of these social and emancipatory movements, as globalization was perceived by many as the dominance of the multinational companies, the globalization of poverty, the spread of 'western values', the consolidation of the economic and military supremacy of the industrialized countries, the monopoly of information gathering and dissemination through western news agencies, the dominance of the one remaining superpower, etc. Hence, it appears that at least one achievement of globalization was a degree of unification of a large number of environmental and social activists and movements on a common platform of "anti-globalization". Although the concept of globalization may mean different things to different people, there is little doubt about some of the positive features of globalization, such as better access to information through the spread of ICT technologies, including the Internet. Nevertheless, in the perception of many, globalization per se has not made the world safer or more equitable, and disappointment about the lack of progress in realizing the substance of the Declaration of Human Rights in the post cold war era, has contributed significantly to the Millennium Declaration adopted by the General Assembly of the UN in September 2000.The Millennium Development Goals recognize that sustainable development is not possible without poverty alleviation and realizing a more equitable world, where the wealth is shared more equitably between nations.

One element in this context was that many people in western countries took an increasingly critical attitude with regard to the Green Revolution, which occurred in the developing world in the 1960's and 70's. The general idea was that during the Green Revolution the benefits went mainly to the richer farmers, with the result that the rich got richer and the poor got poorer. Whether right or wrong, this concept still influences many people's thinking about international agricultural research and development.

In the international development assistance programs of many Western countries, social issues are high on the agenda. Many programs aim at alleviating poverty, abolishing child labour, emancipation of women, protection of human rights, introduction of free-market economies, and establishment of Western-style democracies and civil society organizations. Not all of these topics gel well with local value systems, cultures and religious perceptions, and some forms of social injustice, such as discrimination of women, tribal minorities or lower castes, have been persistent for long times in some societies. Thus it cannot be stated that systems that contain elements of social injustice according to Western norms and values are necessarily unsustainable, but it seems that with better communication and sharing of values worldwide these traditional systems will come under increasing pressure. Hence, it seems that in the long run sustainability cannot be achieved without the full implementation of the Declaration of Human Rights.

RESEARCH AND EDUCATION ON SUSTAINABLE NATURAL RESOURCE MANAGEMENT

In this section some elements of a "paradigm" or "conceptual or methodological framework" for research and education on sustainable natural resource management will be discussed.

THE DEGREE OF SUSTAINABILITY

First it should be noted that we cannot measure sustainability directly. We should not expect to find universal laws that would pertain to sustainability. Sustainability is a quality (or qualification) that we attach to a system. Basically, we assess the degree of sustainability of an agricultural system by comparing a number of properties of that system ("metrics") with a set of specified criteria. The score on the sustainability scale is then a composite index made up of the individual, weighted scores. These "properties" could be the results of ecological or physico-chemical processes occurring in that system, but also the economic viability of that system or the degree to which it contributes to human welfare.

Sustainability is somewhat like the quality of food. We can determine the contents of hazardous compounds in the food and express the analytical results on a scale of zero to one, where one is the concentration above which the food is no longer acceptable for consumption. As long as the ratings do not exceed one, the food quality is acceptable, but the lower the contents of these compounds, the better the quality. Also, we have to assess the taste of the food, for example, with the use of a taste panel. In addition, the food should look nice, etcetera. This example does not suggest that sustainability is something like food quality, but it serves to illustrate that sustainability is a complex notion and that its assessment, on whatever scale, is to some extent based on arbitrary judgments.

The criteria that one uses to assess the degree of sustainability of a system should be reflected in the definition of sustainability. Obviously, the vaguer the definition, the more difficult it will be to quantify the degree of sustainability of a system and the more arbitrary our judgment will be. For example, if it is felt that "enhancing the quality of life" is an important criterion for measuring the degree of sustainability of a particular system, then our judgment will inevitably be somewhat arbitrary, as the "quality of life" is difficult to quantify.

For agro-ecosystems, economic viability and the effect of system dynamics on the environment and the resource base should be the major criteria.

THE TIME SCALES

Although somewhat arbitrary, one could define time scales in relation to sustainability as follows:

Very short term:	**1-5 years**
Short term:	**5-10 years**
Medium term:	**10-20 years**
Long term:	**20-50 years**
Very long term:	**50-100 years**

where "time scale" is used in the sense of "time period considered".

In principle, sustainability can be measured through quantifying the processes occurring in a particular agro-ecosystem, quantifying the interactions between these processes and system components, relating these processes and interactions to environmental and social conditions, and trying to predict the behaviour of such a system over time, using comprehensive simulation models, at specified levels of input and based on certain assumptions with respect to social and environmental conditions, crop varieties, the incidence of pests and diseases, etc.

All of the processes in agro-ecosystems are functions of time and thus relate to certain time scales. One of the reasons why sustainability should be considered "over the long term" is to rule out short-term changes that do not affect the sustainability of an agro-ecosystem. For example, the application of nematicides will affect the soil mesofauna, in particular the nematodes. However, this effect is temporary, and normally after 1-6 months the effect on the soil-ecosystem will no longer be measurable (resilience of the system). Assuming that the nematicide is not preferentially adsorbed in the soil and that the original compound is all decomposed into non-hazardous products, the effect of the application of a nematicide on the agro-ecosystem is very limited or zero, even on the short to very-short term. The application of phosphorus or lime to agricultural soils usually raises the soil contents of P and Ca, respectively, over a period of 1-5 years. That is, there is an effect on the very short term, but not on the short to medium term.

Processes that have a limited effect on the short to medium term, but may have a pronounced effect on the long to very long term are, for example, loss of surface soil due to water or wind erosion, and the salinization of irrigated land. Erosion proceeds usually quite slowly and, depending on the depth of the soil and the nature of the top and subsoil, it may take a long time before soil erosion results in measurable losses in productivity, not caused by losses of nutrients adhered to the soil particles. Similarly, salinization of irrigated soils may be a slow process, depending on such factors as the quantity and quality of the irrigation water, physico-chemical soil properties, the soil water balance (drainage!) and the cropping system.

Another aspect of the time scale is the farmer's perception of changes and measures to be taken. For example, "long term" means 20-50 years, or about a farmer's lifetime. It may thus not always be easy to convince a farmer to adopt practices that ensure sustainability on the long term, because in many cases a farmer will have to give priority the short and very-short term needs for food, fibre, firewood and feed. This points at the problem of adoption of strategies aimed at developing and implementing sustainable agricultural systems: if there are trade-offs between short- and long-term benefits, many (subsistence) farmers have no choice but to opt for the short term benefits.

In order to assess whether a particular agricultural system is sustainable or not, one would have to define that system in terms of time scale, space scale, factors and processes to be considered, etc. In addition, if one wants to assess the behaviour of a system over time, one would have to specify the initial and boundary conditions.

It is clear that there is not one single time scale that is universally valid, or even one time scale that is more relevant than the other: a system that is not sustainable over a period of 5 years is unlikely to be sustainable over a period of 20 or 50 years, unless the direction of some processes changes drastically over time. In addition, the impact that time-dependent processes have on the productivity of a system also depends on the initial conditions. For example, if each year 1 millimeter of surface soil is lost due to erosion, and the soil is 20 cm deep (e.g., a Lithosol), then the impact of this process will be fairly dramatic over a period of 100 years and after 200 years the soil depth is down to zero. If under different circumstances the soil loss would be 5 millimeters per year, but the soil would be 5 meters deep (e.g., a deep loess soil), then after 100 years the effect of the much larger loss of soil (50 cm) on the productivity of the system could be rather limited, provided other properties (e.g., hydrology, soil nutrient status) would not be affected. Hence, the relevancy of time scales depends on the processes or properties studied, and time scales should be applied in a flexible fashion. The assessment of results of time-simulations against specified criteria depends on the initial conditions of the system: not 'all soil loss is equally bad', but 'soil loss from a shallow soil has a relatively larger impact on the resource base and the productivity of the system than soil loss from a deep soil', etc.

THE SPACE SCALES

Sustainable agriculture should also be considered on a certain spatial scale. Similar to what was said about a time scale, processes in soil also refer to space scales. For example, the study of micro-organisms refers to the micro-meter scale, whereas processes in the rhizosphere of a crop may be on the millimeter scale. Oxidation-reduction processes in periodically wet or submerged soils, or the diffusion of oxygen in soils, can be studied on the centimeter scale. The dynamics and distribution of nutrients in soil, following fertilizer application, can conveniently be studied on the scale of the soil profile (meter scale). Spatial variability of soil or crop properties can be studied on the field scale (square meter to hectare).

It is important to note that the way processes are described can be quite different for the different scales. For example, water transport on the micro-meter scale is described by the Stokes-Navier equations. Water movement on the meter-scale is described by Darcy's Law. Though this has been attempted many times, so far it has not been possible to derive Darcy's

Law unequivocally from the Stokes-Navier equations, that is, there is no continuity between the 2 formalisms.

The study of the soil-crop water balance at the meter-scale is again quite different from the water balance in a watershed: in this case the theory may not be different but the scope and scale is completely different. The water balance on the scale of a watershed includes infiltration of rainwater, surface runoff, transport through gullies and watercourses, the effects of silt traps and bunds, the (3-D) movement of shallow and deeper groundwater through different aquifers, the effects of deep wells, the effects of vegetation (crops, trees, natural pasture), etc.

A completely different aspect of the space scale is the following: suppose one advocates the use of animal manures as a source of nutrients for agricultural land. On the scale of a hectare this may seem an attractive proposition: animal manure is an alternative (low-energy) source of nutrients and one can apply sufficient nutrients to compensate for crop removal and nutrient losses, provided animal manure is available in sufficient quantities. This would thus seem a nice sustainable practice. Now consider the scale of a watershed. Animals are likely to graze on marginal (common) lands on the hills surrounding the agricultural lands. These lands are not fertilized and the nutrients removed by the grazing animals are not replenished. Therefore, the fertility of these lands degrades, resulting in loss of vegetational cover and increased erosion of these soils. In addition, as far as nitrogen is concerned, animal grazing is a rather inefficient way of transferring nitrogen from the grazing lands to the agricultural lands, because of the high losses (leaching and ammonia volatilization). In short, on the scale of the watershed, animal grazing results in the rapid degradation of the grazing lands and thus is a highly unsustainable practice.

These examples illustrate that in discussing sustainable agriculture it is useful to define a space scale in addition to a time scale.

The definition of space scales is essential for the evaluation of agricultural systems. It is suggested that the performance of systems could be judged on the following scales (where applicable):

- the profile to field scale (1-100 meters)
- the watershed scale (1-10 kilometers)
- the scale of a suitably defined agro-ecological zone (of the order of 100 kilometers)

The proposed spatial scales would not allow for detailed studies on the functioning of micro-organisms in soils (micro-meter scale) or even mechanistic studies of processes in the rhizosphere (millimeter scale). The proposed scales do allow, however, for studying the following:

- The water balance, including the development and testing of technologies for water harvesting, water conservation, reducing surface runoff, increasing infiltration in soils, increasing crop water-use efficiency, etc.

- The dynamics of nutrients and organic matter, including the development and testing of integrated nutrient management systems, considering atmospheric deposition, making optimum use of fertilizers, animal manures and other organic products, recycling crop residues, optimizing biological nitrogen fixation and the incidence of VAmycorrhiza, selecting crop varieties for optimum rooting properties and nutrient-uptake efficiency, developing cropping systems with shallow and deep rooting species, etc.

- The dynamics of soil and soil structure, as affected by soil tillage, mechanical impact of machinery, soil organisms, weather conditions, etc. The loss of surface soil due to water or wind erosion, and the testing of systems or management practices aimed at reducing soil erosion, such as vegetational covers, bunds, etc. Interactions between the water balance and the soil structure, e.g., surface sealing, water ponding on the soil surface.

- The study of the dynamics of pests and diseases in agro-ecosystems, as affected by soil and crop management, weather conditions and the use of biocides. The chemical and physico-chemical behaviour of biocides in soil-crop systems and the environment. The decomposition rates of biocides in the environment. The study of host-pathogen interactions and the population dynamics of insects and mesofauna (e.g., nematodes), and the functioning of the soil ecosystem at the level of functional groups of organisms. The evaluation of disease- or pest-resistant crop varieties. The testing of integrated pest and disease management systems.

- The study and evaluation of traditional and alternative cropping systems, including the incidence of weeds and the evaluation of techniques for weed control (integrated weed control systems). The evaluation of plant genetic materials under conditions of farmers' fields and farmers' management. Agroforestry and social forestry. The interaction between crops and livestock. The in-situ conservation of plant genetic resources.

- The economic evaluation of farming systems. The assessment of human welfare. The evaluation of systems in terms of impact on women (gender), tribal minorities, etc. The use of (fossil) energy and human labor in farming systems. Short and long term productivity potential, yield and income stability, and equitability. Impact of policies on farmers' decision making. Trade-off values to forego a risky but highly productive system for a lower productive system which is less damaging to the environment.

Each of these processes, management packages or agricultural systems, would have to be studied at the proper space scale. Some of them, such as the water balance, would have to be studied at all three space scales.

THE RESEARCH FOCUS

In addition to defining the time and space scales, one would have to further define the agricultural systems under consideration in terms of inputs, outputs, soil, crop, environmental and social conditions, in order to be able to investigate whether they are sustainable or not. Without going in detail, it will be clear that if the initial conditions of a system (or set of differential equations) are not clearly specified, the behaviour of that system over time cannot be described. Similarly, if the boundary conditions are not specified, the behaviour of a system cannot be described. One would have to indicate, for example, whether carbon dioxide contents, mean temperatures and crop genetic potentials can be taken as constant or that they change over time and, if so, how they change. Of course, predictions could be made for different scenarios, but these examples illustrate that long-term predictions on the behaviour of agricultural systems require detailed information on environmental conditions and technological developments.

The development of improved crop varieties, and the collection and conservation of plant genetic resources remain important elements of the research program. The emphasis might shift more towards breeding for broad adaptability (tolerance to adverse abiotic conditions) and resistance to pests and diseases, rather than breeding for high yield potential per se. The improved plant genetic materials have to be tested at an early stage in marginal environments, in farmers' fields, under conditions of farmers' management.

Breeding for improved crop varieties depends upon assembling new useful combinations within the available genetic variability. However, in the recent past, breeding to ensure high and reproducible agronomic performance has led to increased genetic uniformity. Also most of the hybrids bred for high yield and/or resistance to pests and diseases have been developed from narrow genetic bases. Large scale adoption by farmers of such crops could lead to large-scale disasters when resistance is overcome by a known target pest or disease species. Alternatively, some non-target pests that break out sporadically may adapt to a widely grown cultivar. Hence resistant cultivars will cause the same selection pressure for pest adaptation whether the density of pests is high or low. While monogenic breeding has produced resistance to many pests and diseases, such as yellow rust in rice, Hessian fly in wheat, powdery mildew in barley, sterility mosaic in pigeonpea, fusarium wilt in chickpea and downy mildew in millet, resistance in released varieties may break down over relatively short periods, e.g., of the order of 5-10 years. For sustainable agriculture it might be desirable to breed for cultivars with increased genetic diversity through a wider use of polygenic traits.

Simultaneously, elements of sustainable resource management have to be developed and tested together with the improved crop varieties. These elements include techniques for soil and water conservation, integrated nutrient management, integrated pest and disease management, integrated weed control, cropping systems including a wide range of species to provide food (cereals, pulses, vegetables, fruits), fibre, firewood, construction materials (fences, houses), fodder/animal feed, etc.

The evaluation of the improved crop materials and technology packages should be done by multidsciplinary teams of scientists, consisting of breeders, agronomists, entomologists, pathologists, soil scientists, economists and social scientists. The latter are particularly important in multidisciplinary teams, as they ensure farmers' perceptions are reflected in the evaluation of technologies that are being tested and the design of research strategies.

Once a technology for sustainable resource management would be developed, there would be two directions of further development: one would be the upscaling of the technology for wider application, and the other would be the adaptation and adoption of the technology in a specific environment defined by socio-economic, policy, agroecological parameters. What is referred to here as a 'technology' would basically be a mix of elements of a technology package that would have to be adapted to the local conditions.

Simulation modeling linked to geographic information systems (GIS) would be required to extrapolate the results of resource management research from one agroecological environment to the other. The adaptation, and finally the adoption, of a flexible mix of sustainable resource management technologies at the farm level would require involvement of farmers. Without farmers' participation, no technology will be adopted, and systems that are not adopted by farmers cannot be sustainable. Hence, farmers' participation in the selection of elements and the design and implementation of technology packages is essential. Scientists in academic institutions can assist national programs in developing methodologies for on-farm research, rapid rural appraisals, participatory rural appraisals, reconnaissance surveys, etc.

COMPONENTS VERSUS SYSTEMS APPROACH

From the previous sections it follows implicitly that "systems" have to be studied through studying their "components" and then assembling "systems" through systems analysis, simulation models, or other integrative methodologies. This is because sustainability is a complex notion, or a composite index, that cannot be measured directly. Also, it would be difficult, if not impossible, to describe or model the time-dependent behaviour of systems, comprising of soil, crop, livestock, climatic, socioeconomic, cultural, religious and policy dimensions. Time-simulations of such systems would soon become meaningless, if only because of uncertainties in the initial and boundary conditions over time.

In order to study the sustainability of a system one has therefore to first disaggregate the system. Then one studies the relevant components or processes, such as the water balance of a soil or soil-crop system, the nutrient balances, the energy balance, the fate of biocides in soil-crop systems, etc. Then one compares the results of time- simulations with established criteria for the sustainability of each component. Following that, one determines the interactions between components. For example, the effect of nutrient availability on crop water-use efficiency, the effect of soil tillage on the functioning of the soil biosphere, etc. On the basis of an understanding of components and interactions, one could then assess the behaviour and sustainability of a system.

In principle components per se cannot be "sustainable", because the notion of sustainability refers by definition to a system as a whole and not to individual components of that system. Components, however, can score high on their individual sustainability scale and thus contribute to the sustainability of the system.

Also, each agro-ecological system is site-specific. The extrapolation of results from one agro-ecological environment to the other could be based on simulation modelling and GIS. It may be noted that in simulation modelling too, it is the individual components that one can relate to soil and climatic conditions, rather than the entire system. However, the entire set of component-soil-climate relationships gives a fair indication of the behaviour of the entire system as a function of soil and climatic variables, if properly calibrated and validated.

HIGH- VERSUS LOW-POTENTIAL SYSTEMS

The focus in research and education for sustainable natural resource management will be different for high- and low-potential systems. The benefit/cost ratios are likely to be higher in the high-potential systems, but more research may be needed in the low-potential systems, because they are more diverse in terms of soil, crop, climatic and socio-economic conditions and ecologically more fragile. Resource management packages for high-potential, high-input systems are closer to those practiced at experimental stations, and thus have largely been developed and tested. Low-potential, low-input systems cover a wide range of unfavourable soil and climatic conditions. Environmental concerns are also quite different for the two types of systems, and so are sustainability concerns.

Socially and economically the low-potential areas may also be more complex. There may be tribal minorities living in these areas, or generally more backward and traditional groups of people, which are less educated and have less been in contact with Western technologies than farmers in high-potential areas.

Low potential agricultural production systems may contribute little to the national economy, as measured by GDP are GNI growth. Many of these systems, at best, support a subsistence farmer and his family. In many cases, off-farm income would be needed to ensure a decent living for the farmer and his family, as his land may generate little surplus that can be sold in the market to generate some income. As the potential productivity of these agro-ecosystems is inherently low and as farming under such marginal conditions may lead to degradation of the environment, it would be tempting to recommend that the land be brought under forestry, agro-forestry or some form of pasture, rather than continuing the production of food crops. However, such a recommendation would only be realistic if there would be an alternative for the millions of poor and marginal farmers involved. Most countries in Sub-Sahara Africa and South Asia, where this problem is concentrated, could not offer alternative employment to these marginal farmers and thus for the time being attempts to develop sustainable farming systems for such marginal conditions remain relevant.

ENHANCEMENT OF ENVIRONMENTAL QUALITY AND THE RESOURCE BASE

The primary objective of agriculture is not to enhance the resource base on which agriculture depends, nor to enhance environmental quality. This does not imply, however, that among farmers in developing countries there would be no awareness of the need to enhance the resource base and the quality of the environment. In particular women farmers seem to be acutely aware of the state of the environment and the services provided by the environment. This is not surprising, knowing that in many developing countries women farmers are responsible for carrying water from the well to the house, for collecting firewood for cooking and heating, for collecting fodder for animals, and, above all, for feeding the children. When the groundwater levels drop and wells fall dry, women have to walk farther to find wells that still have water and have to lift up the water from greater depth. When the water quality deteriorates, women farmers are the first to find out, through the taste of water and food or diseases of their children. When trees are cut or die for other reasons, and no saplings are planted, women farmers have to walk farther to collect the ever scarcer firewood. Similarly, the availability of fodder is to some extent a reflection of the quality of the environment and the resource base, and again women farmers are the first to find out. Finally, because of the children and the animals, women farmers are more bound to the villages than the men, who go to the cities for work more easily than the women. These considerations may help to explain why in a number of cases women farmers seemed to be more susceptible to concepts of soil and water conservation, social forestry, etc. than men farmers in the same villages. However, the enhancement of the resource base requires investments in terms of organization, human labour, materials (e.g., saplings) and money (e.g., for chemical fertilizers, pumps, fuel). In many cases the farmers themselves will not be able to develop or sustain programs for the enhancement of the resource base, without outside assistance of government bodies or NGO's, for financial as well as organizational support.

TOTAL FACTOR PRODUCTIVITY

It has been mentioned before that a system that is not economically viable cannot be sustainable. If a system does not sustain the people that form part of it, it cannot be sustainable. Of course, this is not specific for sustainable systems, it would apply to any kind of development model: systems that are not economically viable will ultimately disappear. The matter of subsidies is not considered here, but it should be noted that subsidized systems can be sustainable if (and as long as) the society is prepared to pay for them. For example, ecological (or: eco-friendly) agriculture in Switzerland is heavily subsidized, because the millions of tourists that visit Switzerland every year in the spring and summer, like to see cows in alpine meadows, haystacks, and whatever contributes to the beauty of the 'typical' Swiss landscape. Hence, even though this form of agriculture and the maintenance of the landscape is heavily subsidized by the Swiss government, this system would be sustainable as long as the tourism sector pays for this.

Total factor productivity (TFP) is a useful concept in measuring the productivity of agricultural systems. It is a necessary condition for economic viability, since it is measured in value terms, but it is not sufficient as a measure for sustainability. An example will illustrate. Suppose that at a constant level of inputs, the crop yields decline, that is, the productivity of the land decreases. Now assume that the prices of the crops increase in such a way that the income of the farmer remains the same in real terms (TFP=constant). Then the system would seem sustainable, but only from the economic point of view. From the physical/biological point of view, the system is unsustainable, because the productivity of the land decreases (possibly because of the build-up of diseases, micronutrient deficiencies, soil erosion or deterioration of the soil structure). The reverse situation is also conceivable. Yields may increase as a result of more efficient use of resources (energy, labour, nutrient use efficiencies). But if the prices go down, the income may remain constant. Thus, from an economic point of view, the system does not change over time. From a physical/biological point of view, the productivity of the land would increase, which means the system would do very well on the sustainability scale.

CONCLUSION

The concept of sustainability had strong international dimensions from the outset. The concept emerged first in the industrialized world and was then introduced in other parts of the world. Concern about the environment, the perception that there were limits to economic growth, the need to conserve biodiversity and a range of social and political issues, such as democratization of institutions and governance systems, emancipation of women and minority groups, as well as the decolonization process and the end of the cold war, all contributed to the complex notion of sustainability. Basically all of the above have strong international dimensions and are linked to globalization. Clearly, environmental problems such as pollution of the seas and oceans, the decomposition of the ozone layer and climate (linked to CO_2 emissions worldwide) are global problems. The global economy is probably the most globalized sector of all items considered. The globalization of the economy provides challenges and opportunities to many developing or transitional economies. Biodiversity conservation of plant species and especially of animals has global dimensions, for example, the conservation of whales and migratory birds. Finally, many (if not all) of the social and political issues that are considered relevant to the emergence of the concept of sustainability are global in nature: democratization, emancipation and, more recently, the 'antiglobalization' movement, as well as decolonization and the post war history (the cold war) are all global par excellence. Hence, it is no surprise that the United Nations took the lead in the discussion on sustainable development, first through the World Commission on Economy and Development, chaired by Gro Harlem Brundtland, who defined in its first report in 1987 sustainable development as a development "which meets the needs of the present without compromising the ability of future generations to meet their own needs". The publication of the WCED report in 1987 was followed by many other international events and culminated in the world conferences of Rio de Janeiro (1992) and Johannesburg (2002), and the adoption by the Millennium Declaration by the General Assembly of the UN in September 2000.

An important component of sustainable development is the sustainable management of natural resources (NRM) and the conservation of the bio-physical environment. Agriculture is the most important economic activity in the rural space and therefore any natural resource management system that is not economically viable, i.e., does not provide a livelihood to a farmer and his or her family is by definition unsustainable. Another observation is that sustainable NRM has social-economic as well as biophysical aspects and that in practice there may be a trade-off between these two sets of criteria. Sustainability as such cannot be measured, as it is a complex or composite index, which can be measured only by quantifying its component factors or processes, assessing their values or performances against a series of established standards, and then derive an estimate for the sustainability of the aggregated system. In addition, most if not all component processes of sustainability in relation to NRM are functions of time and space. It is therefore important to define the time and space scales when one studies sustainable NRM in relation to natural systems.

Research and education in sustainable NRM encompasses practically all scientific disciplines in the natural and socio-economic sciences, and thus have benefited from the unprecedented spread of ICT technologies in the past decades, most prominently the Internet, and the increased mobility of scientists worldwide. Although globalization has been questioned in relation to its social and economic aspects (cf. the anti-globalization movement), there is little doubt that its overall effect on science and technology related to sustainable management of natural resources has been positive, mainly through increased access to information, including satellite imagery at low cost or free of charge on the Internet, access to highly effective low-cost means of communication, the sharing of ideas and the exchange of academics, and the decreasing costs of gadgets such as cell phones and computers. Of course, in the low-income countries of South Asia and Sub-Saharan Africa, a large segment of the society does not benefit from the opportunities provided by globalization, because of poverty and lack of access to basic amenities, such as electricity. Also, for the same reasons, technologies such as distance education have not made much headway in the poorer and more remote areas of the world. Hence, it is good to realize that technologies *per se* cannot solve socio-economic or governance problems, only people that make intelligent use of them can solve developmental problems.

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STUDENTS BECOMING SCIENTISTS IN THE WORLD: INTEGRATING RESEARCH AND EDUCATION FOR SUSTAINABLE DEVELOPMENT

INTRODUCTION

Many universities, research institutes, and medical centres are discipline-based. There are many calls to complement this model with integrative, interdisciplinary, and collaborative programs to better address societal challenges and to advance our basic understanding of natural systems (e.g.,[1,2]). In areas with rapidly advancing knowledge as in so many of the sciences, we might expect networks of scholars to be fluid, disbanding and reforming in response to a quickly changing understanding of the world. In reality, departments and institutions often retain a historical rigidity that has less to do with organizing around communities of knowledge and more to do with the competitive advantages that accrue to those who can exploit the absence of change. This sort of rigidity would seem to be especially unfortunate as we think about science and technology education for sustainable development.

At the start of the 21st century scientific research is increasingly characterized by two basic ideas. First, disciplinary silos alone are not the best model for advancing knowledge. Today's challenges demand a more flexible model that promotes ebb and flow from disciplinary to interdisciplinary endeavours, from narrowly reductionist to broadly integrative programs that might include natural, physical, and social sciences, the arts, humanities, engineering, business, and law. Second, this flexibility cannot be realized solely within most current academic organizational models. Instead we need *collaborative networks* that use computer and information technology (i.e., cyberinfrastructure) to take advantage of the mobility that is so common in today's world. We must also educate people—young and old— to be able to work within and take advantage of such global networks.

Research and training programs form a spectrum from narrowly specialized disciplinary programs at one end to integrative at the other—the full spectrum works best to advance knowledge. Researchers and training opportunities may find their primary home in one portion or another of the spectrum, but all can benefit from interactions with other parts. If learning is the creative process by which new knowledge is discovered, how do we teach both faculty members and students that this process often means transcending single academic disciplines, even institutions? What should programs look like to allow students to master a body of scholarship, while accepting that disciplinary borders may be too constraining and that questions are often best answered through the intellectual fusion that comes from mastering knowledge as needed regardless of boundaries?

We need faculty members and students who think about knowledge-driven outcomes and how to achieve them within environments that may impose constraints on discovery. In addition, the humanities and social sciences bring important perspectives to the scientific enterprise. The scholarship that comes closest to achieving this vision requires *networks of individuals* who develop disciplinary and interdisciplinary ideas and then test them against widely different worldviews. In the parts of the world where education and research are separated into different institutions, there are even greater challenges to integrate education and research, and then to integrate across the disciplines.

Training programs are needed for students, faculty members, and non-university professionals who will work in just these sorts of networks. To be scientists in and for today's world students must learn to be essentially "knowledge entrepreneurs," discovering new knowledge while functioning in a broad, diverse network of scholars and institutions. Faculty members and mentors must learn to work in a different world than the one they may have been trained to confront. How can we make this happen given the conservative constraints of traditional research universities and research institutes?

This approach is particularly important in the context of sustainable development. For an issue that is global in scope and import, solutions will require advances within and connections between all areas of science, the humanities, and technology. The mission of the National Science Foundation (NSF), which is to foster basic discoveries across all fields of science and engineering research integrated with science education at all levels, is congruent with these needs and approaches. Many projects funded by the NSF focus on questions of broad international concern that are important to sustainable development worldwide, including for example the spread of infectious disease, natural resource management, agricultural technologies, and computer and information technology that enable intellectual mobility. What follows are a series of NSF programs that address networking in diverse ways.

EDUCATIONAL PROGRAMS

NSF is committed to supporting the development of a globally-engaged scientific and technological workforce that will be prepared to succeed in a global knowledge economy. Because this is a core value for the NSF, international projects are a component of programs that support education more broadly, as well as those that are specifically designed to create an international experience. For example, the **Research Experiences for Undergraduates program** seeks to expand student participation in research that contributes to the NSF goal of developing a diverse, internationally competitive, and globally-engaged science and engineering workforce. Several of the projects funded through this program have international components, and the Nyanza Project in particular illustrates an interdisciplinary, international research training experience[3]. The Nyanza Project, which is run on the shores of Lake Tanganyika in Tanzania, is a seven-week research training program for American and African students, with the goal of providing undergraduates, graduate students, and high school teachers with the skills to plan and conduct interdisciplinary research on the paleoclimatology, geology, limnology, aquatic biology and watersheds/conservation of tropical lakes. With funding from African sources and the NSF, 89 undergraduates, 24 graduate students, and 8 high school teachers from the U.S. and 58 African students (from Tanzania, Burundi, Zambia, Congo, Kenya, and Burkina Faso) have participated in the project over the last eight years.

Building capacity in cyberinfrastructure is critically important for scientists worldwide to conduct their research and educate their students. One example of how the use of cyberinfrastructure and collaborative networks is transforming traditional pedagogical approaches is the **nanoHUB**[4]. The nanoHUB is a web-based initiative spearheaded by the **Network for Computational Nanotechnology**, a network of universities and researchers who work collaboratively to connect theory, experiments, and computation to advance the field of nanotechnology. The nanoHUB provides online simulation services as well as courses, tutorials, seminars, debates, and facilities for collaboration—the use of cyberinfrastructure tools to integrate nanotechnology research into education transcends many barriers. This resource registers more than a million visitors a month, with nearly half coming from a dozen different countries other than the U.S., including India, China, Korea, Taiwan, Japan, Singapore, Canada, and several European countries. Also, NSF's **International Research Network Connections Program** is working with peer groups around the world to develop a global integrated network environment, and links to GÉANT and CLARA, the European and Latin American regional research and education networks.

The **Pan American Advanced Study Institutes program** brings U.S. and Latin American graduate students and post-doctoral fellows together to stimulate cooperation among researchers in the Americas in engineering and the mathematical, physical, and biological sciences. Recent topics have included ion nanobeams, advanced networking technologies for physics and astronomy, bioinspired nanoscience and molecular machines, and mathematical models of population dynamics. These short courses provide unique opportunities for students and investigators from the United States and Latin American countries to forge new connections and networks, and to explore new interdisciplinary fields of science and technology.

One last example of an educational program at NSF that promotes global engagement of students is the **International Research Experiences for Students (IRES)** activity, part of the **Developing Global Scientists and Engineers Program**. The IRES activity supports projects that create opportunities to introduce small groups of U.S. undergraduate and/or graduate students to international science and engineering in the context of a research experience that also provides personal contacts on which to build future international collaborations. The goal is to provide U.S. student participants with a global perspective and opportunities for professional growth through international cooperative research training, networking, and mentoring. Current IRES projects offer opportunities in Japan, Thailand, Austria, Brazil and Costa Rica, in areas within engineering and the biological, mathematical, and physical sciences.

RESEARCH PROGRAMS

One of NSF's long term investment priorities is to foster research that focuses on living sustainably on the Earth. Studies range from investigations of deep oceans to urban centers, and from basic energy science to climate science with the goal of improving our understanding of the links between human behavior and natural processes. As the world's economies grow increasingly interdependent, international research partnerships are growing in importance. The ability to develop collaborations that create new value for the partners is often the limiting factor for progress in critical areas of science, engineering, and technology. NSF uses research grants to support the development of international partnerships that foster cooperation, build global research capacity, and advance the frontiers of science.

For example, within our own Directorate for the Biological Sciences, the **Plant Genome Research Program (PGRP)** supports collaborative research linking U.S. researchers with partners from developing countries to solve problems of mutual interest in agriculture, energy, and the environment, while building a global network of scientific excellence. The long-term goal of these collaborative efforts is a greater and sustained engagement with developing countries in plant biotechnology research. Since this aspect of the PGRP began in 2004, 17 projects in 10 countries (Bolivia, Brazil, Colombia, India, Mexico, Nepal, Nigeria, Peru, Philippines, Sri Lanka) have been supported, many of which include reciprocal exchanges of students and investigators. The research focuses on issues of local interest such as biotic and abiotic stress, and on local crops such as oil seed Brassica, rice, and chickpeas. One of these collaborative projects has led to an international workshop at which scientists from the U.S. and India joined together to develop an international initiative on using genomics technology to improve three legume species of agricultural and economic importance to both countries.

Also within the Directorate for the Biological Sciences, the **Ecology of Infectious Diseases (EID) Program** supports a number of interdisciplinary projects with collaborative links to countries in Africa, Mexico, the Caribbean, and Bangladesh. The goal of the EID program is to encourage development of predictive models and discovery of general principles for relationships between anthropogenic environmental change and the transmission and evolution of infectious agents. These problems frequently are global in nature, and the research requires international collaborations for successful outcomes. For example, one early EID project was designed to provide insights into the spread of tuberculosis, which has been exacerbated by the current AIDS epidemic in Africa. This project focused on bovine tuberculosis in the African buffalo population in the Kruger National Park, South Africa, and the spill over of this disease to cattle and humans living on the boundaries of the park. The results of the research, which found that the rate of spread during an epidemic can be highly determined by a few individuals (called "superspreaders) that are responsible for most of the transmissions among individuals, have significant implications for disease management. To accomplish the goals of the project, a multidisciplinary team of U.S. and African scientists and students (including post-doctoral fellows, graduate students, and undergraduates), consisting of epidemiologists, microbiologists, veterinarians, ecologists, molecular biologists, and geneticists formed an international collaborative network—the students involved had an extraordinary opportunity to become engaged in a global problem through this research effort. As a result of their experiences, several of the students are continuing to work on international issues after receiving their degrees.

Over the last ten years, NSF has been working to build a network of materials research scientists in the developed and developing world. The **Materials World Network**[5] is a global community of researchers and educators working across borders and disciplines to accelerate materials discovery and design. Materials scientists are designing and engineering materials by building in special properties. Such new materials may help to increase energy efficiency, promote green manufacturing, improve health care, develop information and communications systems, and provide modern and reliable transportation and civil infrastructure. To maximize the global benefits, NSF joined with partners from abroad to establish the Network, which now reaches nearly every region of the world. The Network brings together a diverse community to address global challenges through materials research, technology, and education.

A new pilot program that NSF began last year is called **Partnerships for International Research and Education**, which supports the development of collaborative relationships between U.S. institutions and international organizations to advance research and education goals that could not be accomplished in the absence of the partnership. The first round of awards spanned a wide variety of research areas, all of which shared the common characteristic that success will require collaboration with foreign partners. These awards hold the promise of creating new models for international engagement through academic research, and will provide strong international research experiences for the students and post-doctoral fellows that will be involved in conducting the research.

CONCLUSION

The NSF invests in a wide variety of research and education efforts in its quest to fulfil its mission. Increasingly, in an era of globalization and interdisciplinary approaches, we need new paradigms in science and technology education that will enable the next generation to acquire not only the necessary skills and knowledge base to succeed, but also an appreciation for the international and interdisciplinary context within which science and technology operate. Creating a culture in which dynamic networks of individuals that span disciplines, institutions, and countries can form easily, enabled by cyberinfrastructure advances, will help these students become globally-engaged in a meaningful way. Only then can we hope to gain traction in solving the global challenges, including sustainable development that confront the nations of the world.

ACKNOWLEDGMENTS

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Notes

1. Aldhous, P. 2002. Harvard's melting pot. *Nature* 416: 256-257.

2. Krull, W. 2002. A fresh start for European science. *Nature* 419: 249-250.

3. http://www.geo.arizona.edu/nyanza/

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Conference participants

Monthip Sriratana Tabucanon and **Nagia Essayed** share a light moment with **Her Royal Highness Princess Maha Chakri Sirindhorn** at the reception.

Hiroshi Nakada

Mayor of Yokohama

Hans van Ginkel

UNU Rector

Hans d'Orville

Director, Bureau of Strategic Planning, UNESCO

ANNEXES

CONFERENCE BACKGROUND PAPER GLOBALIZATION: CHALLENGES AND OPPORTUNITIES FOR SCIENCE AND TECHNOLOGY

BACKGROUND

Globalization refers to increasing cross-border movements of goods, money, information and ideas as well as people, and to an ensuing interdependency of people and institutions around the world. This interconnectedness changes the living conditions and perspectives of current and future generations. It creates, at one and the same time, both opportunities and challenges.

Science and technology drive globalization processes: New information and communication technologies, for example, contribute to the infrastructure that enables people, goods and information to navigate the globe. At the same time, the ways in which scientific knowledge and new technologies are produced is strongly influenced by globalization: Research and development agendas are defined not only by the problems in our immediate vicinity, but by the requirements of a global marketplace; researchers scattered across the globe jointly work on common projects; and the speed of knowledge diffusion profoundly changes the way in which knowledge is created. The creation of and access to knowledge, in fact, have become crucial factors for economic and social progress.

OBJECTIVES

Against this background, the conference aims at providing a forum to discuss ways in which to better, and more directly, harness scientific and technological progress for the promotion of peace and sustainable development. In exploring these changing roles of science and technology, the conference will explore salient issues such as access to knowledge and benefit sharing, the scope of intellectual property protection, or the ethical boundaries of scientific enquiry. At the centre of the discussions will be the creation of knowledge societies in which science and technology are neither the realm only of academics in their ivory towers nor where the products of scientific achievement are enjoyed merely by a limited elite. Rather, the conference aims to delineate the parameters of knowledge societies that utilize the processes of globalization to foster knowledge creation and diffusion for the benefit of all.

STRUCTURE

The conference will begin with a public symposium in which eminent experts from politics, the United Nations, academia and the private sector will discuss the ways in which globalization changes science and technology, and vice-versa, and the opportunities these changes offer for better utilizing science and technology to foster peace and sustainable development world-wide. Following the public symposium, a series of parallel workshops will be held on the different process through which science and technology link with and contribute to peace and sustainable development. The workshops will be structured around the topics of: knowledge sharing, trade and technology transfer, society and policy-making and Education for Sustainable Development.

CONFERENCE PROGRAMME

DAY 1

PUBLIC SYMPOSIUM

10:00 -10:30

OPENING REMARKS AND INTRODUCTION

- **Koïchiro MATSUURA**, Director-General, United Nations Educational, Scientific and Cultural Organization (UNESCO)
- **Hans van GINKEL**, Rector, United Nations University (UNU)
- **Masayoshi YOSHINO**, Vice Minister, Ministry of Education, Culture, Sports, Science and Technology, Japan
- **Akiko YAMANAKA**, Vice Minister for Foreign Affairs, Member of the House of Representatives, Japan

10:30-13:00

KEYNOTE PRESENTATIONS: SCIENCE & TECHNOLOGY, GLOBALIZATION, AND HUMAN DEVELOPMENT AND SECURITY

Co-Chairs: Koïchiro MATSUURA, Director-General, UNESCO, and Hans van GINKEL, Rector, UNU

Five keynote speakers will present an overview of the changing roles of science and technology in peace and development. A brief Q&A period will follow each presentation.

- **Science, Technology and Development**
  Her Royal Highness Princess Maha CHAKRI SIRINDHORN
- **Globalization and the Knowledge-based Society**
  Kandeh YUMKELLA, UNIDO Director-General (TBC)
- **Contemporary Challenges of Science and Technology – an African Perspective**
  Nagia ESSAYED, Commissioner for Human Resources, Science and Technology, African Union
- **Science and Technology for a Better World: Retuning the Role of Science**
  Koji OMI, Member, House of Representatives, Japan (confirmed)
- **Science, Technology, Peace and Security**
  Goverdhan MEHTA, President, International Council for Science (ICSU)
- **Science, Technology, and Environmental Challenges**
  Hama Arba DIALLO, Executive Secretary, United Nations Convention to Combat Desertification (UNCCD)

13:00-15:00 | LUNCH

15:00-18:00 | PANEL DISCUSSION: GLOBALIZATION, NEW TECHNOLOGIES, AND SOCIETY

Co-Chairs: Kiyoshi KUROKAWA, President, Science Council of Japan, and Hans D'ORVILLE, Director, Bureau of Strategic Planning, UNESCO.

Panellists will explore the impacts of globalization in different areas of science and technology, focusing on the relevance of globalization in each respective field and the contributions of this field to peace and development.

- **Scientific and Technical Cooperation**
  Ana Maria CETTO, Deputy Director-General and Head, Department of Technical Cooperation, International Atomic Energy Agency Scientific and Technical Cooperation
- **Energy**
  Sameer MAITHEL, Director, Energy-Environment and Technology Division, Tata Energy Research Institute (TERI)
  Video: English (00:20:50)
  Video: Japanese
- **Globalization, Information Technology, Peace & Development: Challenges and Opportunities for Sub-Saharan Africa**
  Maurice TCHUENTE, Board Chairman of the National Agency for Information and Communication Technologies, Cameroon
- **The Case for ICT and Health**
  Abdel-Salam MAJALI, President of the Islamic Academy of Sciences (IAS), Jordan
- **Strategies for Developing Countries**
  Turner ISOUN, Minister for Science and Technology, Nigeria

18:30 | RECEPTION

DAY 2

WORKSHOP: LINKING GLOBALIZATION, SCIENCE AND TECHNOLOGY FOR PEACE AND SUSTAINABLE DEVELOPMENT

The workshop focused on the processes through which science and technology link with — and contribute to — economic and social development, and the ways in which globalization impacts on these processes.

10:00-10:45

OPENING SESSION

Opening remarks, and clarification of the workshop structure and aims by the Chairperson

- A.H. ZAKRI, Director, UNU Institute of Advanced Studies (UNU-IAS)

10:45-11:00

COFFEE BREAK

11:00-13:00

PARALLEL WORKSHOP SESSIONS

1. WORKSHOP SESSION 1:
   KNOWLEDGE-SHARING

   Chair: Itaru YASUI, Vice-Rector for Environment and Sustainable Development, UNU

   Rapporteurs: Fan Peilei, Wang Yanqing, Sofia Hirakuri

   Presenters:

   - **Enhancing Information And Knowledge Sharing For Poverty Reduction**
     Andrew Barde GIDAMIS, Executive Secretary, African Institute for Capacity Development (AICAD), Kenya
   - **Knowledge Sharing: A Global Challenge**
     Luc SOETE, Director, UNU Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT)

2. WORKSHOP SESSION 2:
TRADE AND TECHNOLOGY TRANSFER

Chair: Ana Maria CETTO, Deputy Director-General and Head, Department of Technical Cooperation, International Atomic Energy Agency

Rapporteurs: Claudia ten Have, Ademola Braimoh, Rebecca Carter

Presenters:

- **Trade and Technology Transfer**
  Gary P. SAMPSON, UNU-IAS Chair of International Economic Governance; former Director, Trade & Environment Division, World Trade Organization
- **Intellectual Property and Technology Transfer in Biotechnology: The Experience of ICGEB**
  Decio RIPANDELLI, Director, Administration and External Relations, International Center for Genetic Engineering and Biotechnology (ICGEB)

3. WORKSHOP SESSION 3:
SOCIETY AND POLICY-MAKING

Chair: A.H. ZAKRI, Director, UNU Institute of Advanced Studies (UNU-IAS)

Rapporteurs: Catherine Monagle, Clarice Wilson, Christopher Kossowski

Presenters:

- **A Global Perspective**
  Issa KALANTARI, former Minister of Agriculture, Iran
- **Strategies to Integrate Traditional and Modern Knowledge**
  Douglas C. PATTIE, Environmental Affairs Officer, United Nations Convention to Combat Desertification (UNCCD)
- **Linking Globalization, Science and Technology for Peace and Sustainable Development**
  Akihiro ABE, Professor, Center for Nano-Science and Technology, Tokyo Polytechnic University

4. WORKSHOP SESSION 4:
SCIENCE AND TECHNOLOGY EDUCATION FOR SUSTAINABLE DEVELOPMENT

Chair: Mohamed H.A. HASSAN, Executive Director, The Academy of Sciences for the Developing World (TWAS)

Co-chair: Nagia Essayed (Commissioner for Human Resources, Science and Technology, African Union Commission) and Katsunori Suzuki (Senior Fellow, UNU Institute of Advanced Studies).

Rapporteurs: Yoko Mochizuki, Maki Katayama

Presenters:

- Monthip Sriratana TABUCANON, Deputy Permanent Secretary, Ministry of Natural Resources and Environment, Thailand
  Sustainable Development and the Sufficiency Economy: Role of Science and Technology
- Karl HARMSEN, Director, UNU Institute for Natural Resources in Africa (UNU-INRA)
  Sustainability Natural Resource Management
- James COLLINS, Assistant Director for the Biological Sciences Directorate, National Science Foundation, USA
  Students Becoming Scientists in the World: Integrating Research and Education for Sustainable Development

13:00-14:30 **LUNCH**

14:30-17:00 **POLICY RECOMMENDATION DISCUSSION FOLLOWED BY CLOSING REMARKS**

Co-chairs: Hans van GINKEL, Rector, UNU; Hans D'ORVILLE, Director, Bureau of Strategic Planning, UNESCO

Harnessing the full potential of science and technology for sustainable development implies a strong focus on global knowledge exchange, networking, and advocacy. UNESCO has a unique capacity in these areas, in particular with respect to facilitating cooperation at the international level. Scientific knowledge and technological innovations must be oriented to ensure human welfare.

Koïchiro Matsuura, Director-General of UNESCO

While globalization processes are, in part, driven by science and technology; globalization, in turn, has strongly influenced the ways in which scientific knowledge and new technologies are produced and disseminated. It is important to explore the relations between globalization and the development of science and technology so as to improve the human condition everywhere.

Hans van Ginkel, Rector of UNU

United Nations
Educational, Scientific and
Cultural Organization

For further information about UNESCO's activities related to globalization, please see:
www.unesco.org/bsp/globalization

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